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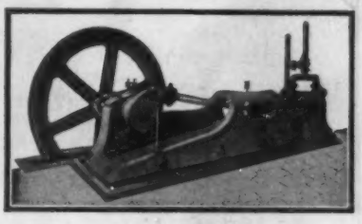

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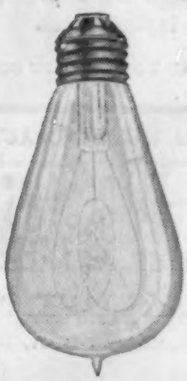

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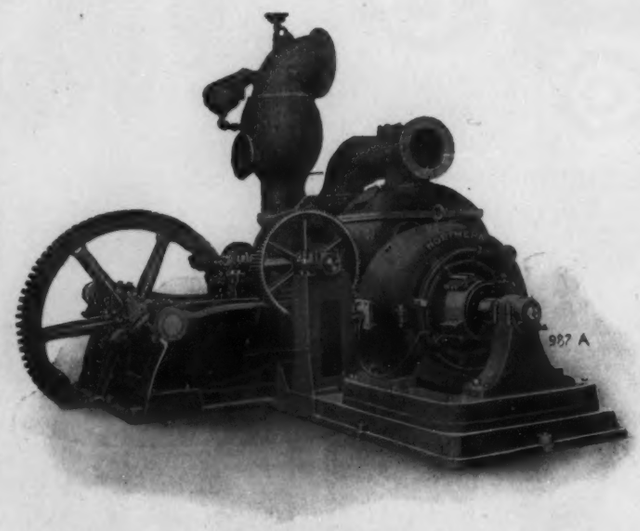

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Devoted to the Conversion, Transmission and Distribution of Energy.

VOLUME XIV. SAN FRANCISCO, CAL., NOVEMBER, 1904. NUMBER 11

*High Potential Long Distance Transmission and Control.**

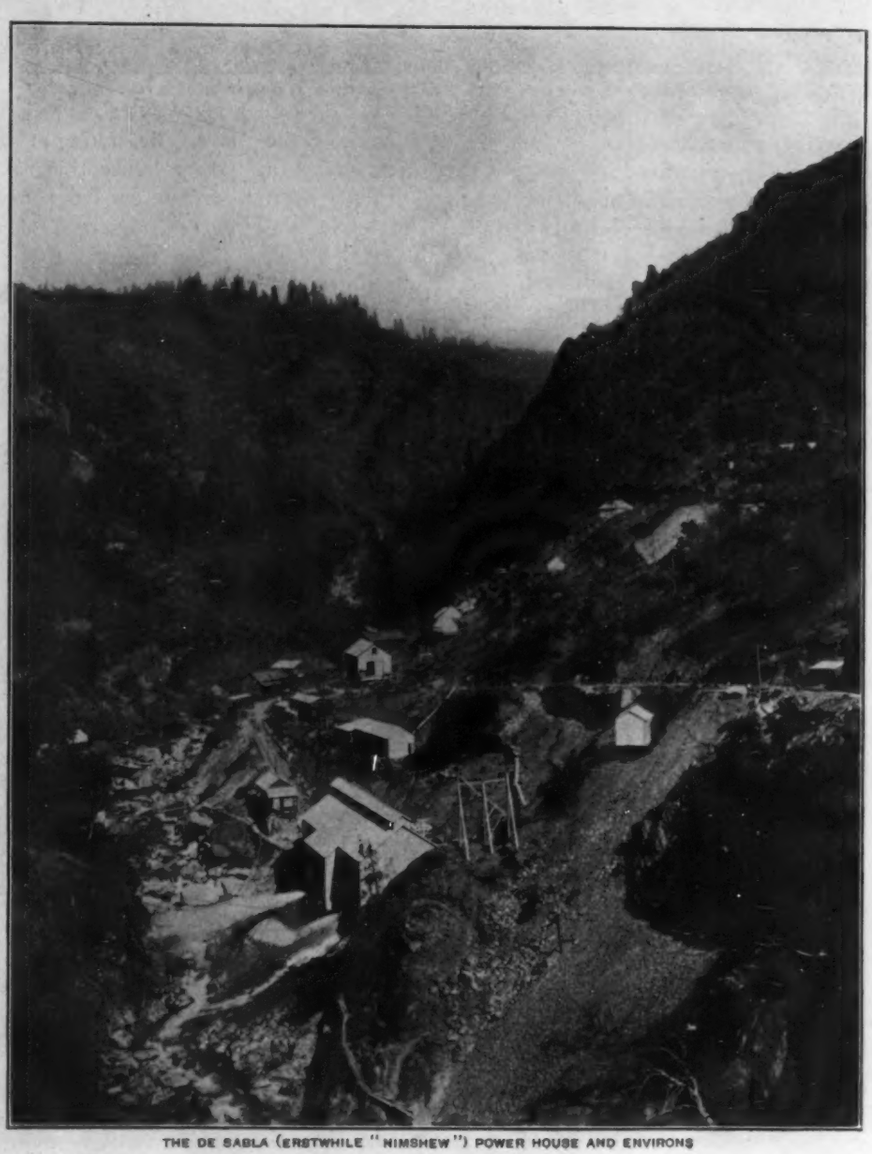
BY F. G. BAUM.

[WITH AN INTRODUCTION, BY THE EDITOR, ON THE DE SABLA POWER PLANT.]

PREFATORY to the invaluable paper presented by F. G. Baum to the International Electrical Congress, and which follows, it is of interest to briefly detail some of the important features of the de Sabla power plant of the Valley Counties Power Company, which Mr. Baum describes, with particular reference to its most excellent interior high tension switching arrangements.

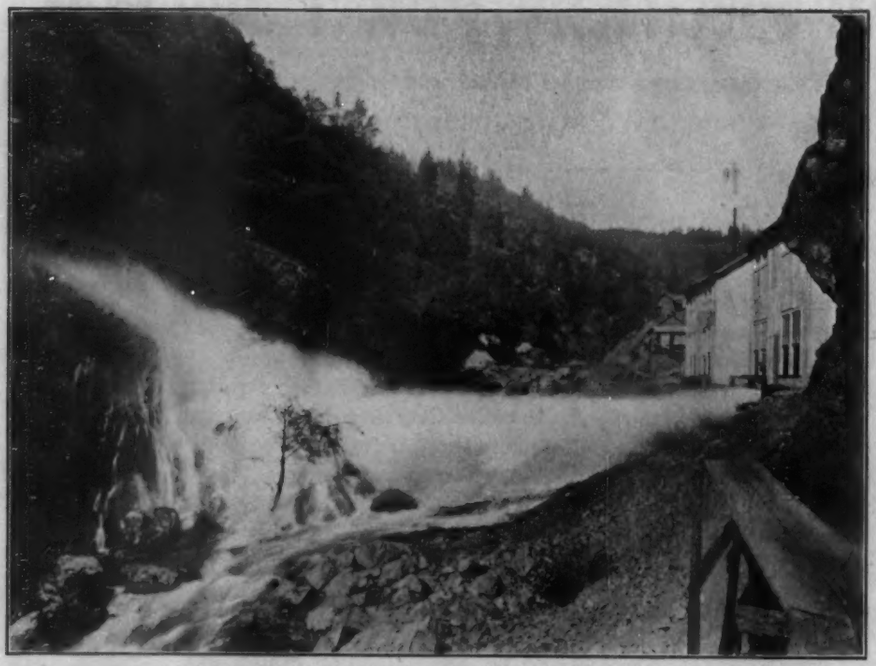
Eight miles by way of the road above the Centerville power house of the Valley Counties Power Company, and which in turn is sixteen miles east by southeast of Chico, and in Butte County, California. and so far down in the narrow canyon of Butte Creek that the sun reaches it but five hours a day at the most, is situated the de Sabla power house. During its construction the plant was known as Nimshew, the name of an Indian tribe which, though now extinct, formerly occupied the section of the country which the plant and its water system embraces. In design the installation is plain and modest, but potent in every detail, and among its most striking peculiarities are the high head under which its wheels are operated, its extreme simplicity of arrangement, its mammoth water wheel and generator unit, and its seemingly perfect high tension arrangements.

Nimshew, the postoffice for the plant, is an old settlement at the top of the hill within two miles of the reservoir, whence a three and one-half mile road that forms a boulevard in the perfection of its construction and in the grandeur of its course down into the canyon, leads to the power house. A direct route thereto is by way of the trail, which goes down almost precipitously to the power house in a route which, though less than a mile in length, drops over 1700 feet in the distance. Water for the operation of the plant is taken mainly from Butte Creek, having a capacity of 3000 inches, by the so-called Cherokee ditch, to which the Toadtown ditch contributes an additional 1000 miner's inches of water that is brought over from the west branch of the Feather River. The ditch system in all covers a length of some forty odd miles, of which about thirteen miles is embraced in the main ditch. The reservoir at the head of the



THE DE SABLA (ERSTWHILE "NIMSHEW") POWER HOUSE AND ENVIRONS

*A paper presented before the International Electrical Congress, St. Louis, Mo., September 12-17, 1904.



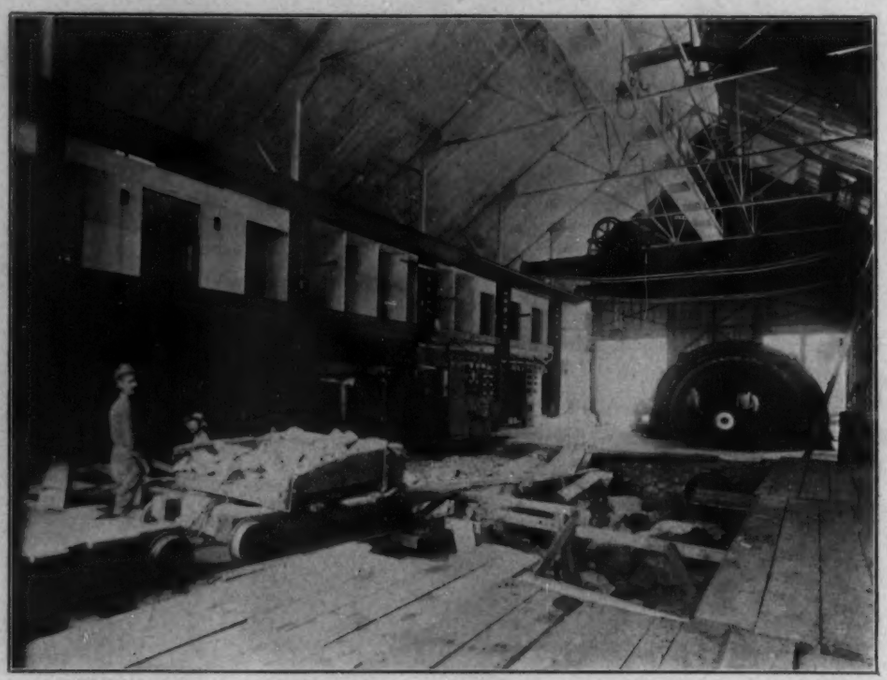
A SINGLE THREE-INCH JET IN OPEN DISCHARGE UNDER A STATIC HEAD OF 1560 FEET

pipe line, which has a capacity of about 9,000,000 cubic feet of water, is confined by an earth-filled dam having a height of fifty-four feet above the head-gates of the main pipe lines. This reservoir was designed to safeguard the ditch and to tide over the plant under peak load conditions. The source of water supply is unfailing with reference to the installed capacity of the plant, in view of which no effort is made toward conserving the water for use during dry seasons.

Two pipe lines lead from the reservoir to the power house, the first of which has been in operation for a little over a year. This line is 6003 feet in length, the upper section of which, amounting to 4400 feet, is laid on a hydraulic grade of twenty-eight degrees from the reservoir to a location known as Common Point. This first section is all of steel riveted pipe running from nine-sixteenths of an inch to No. 10 in thickness, the pressure at its lower end being 350 pounds per square inch. From Common Point section No. 2 continues down on to the power house at a distance of about 1600 feet further at a gradient of thirty-two degrees fifteen minutes. Approximately one-half of this distance is tunneled, and from Common Point lap welded flange tubing is used through to the power house. Its thickness tapers from one-half inch at Common Point to three-quarters of an inch at the lower end, and the last 190 feet has been tested to a hydrostatic pressure of 1000 pounds per square inch. The diameters used on these pipe lines are thirty inches inside measurement for all riveted pipe and thirty inches outside measurement for all lap welded pipe, with the exception of a few trestles which are built on standard railroad specifications, and the longest of which is 180 feet, the entire pipe line being either buried in a trench or run through tunnels that have since been filled in.

Pipe line No. 2 is practically a counterpart of the foregoing, in so far as the specifications of the pipe itself are concerned, the main difference between them resting in the fact that No. 2 is run almost continuously in tunnels. Beginning at the point where the tunnel enters the power house this tunnel is run into the mountain at a grade of one foot per rod for a distance of 250 feet, whence it continues upward at an incline of thirty-three degrees fifteen minutes for 1568 feet, whence it is carried to the reservoir along a course parallel to pipe line No. 1.

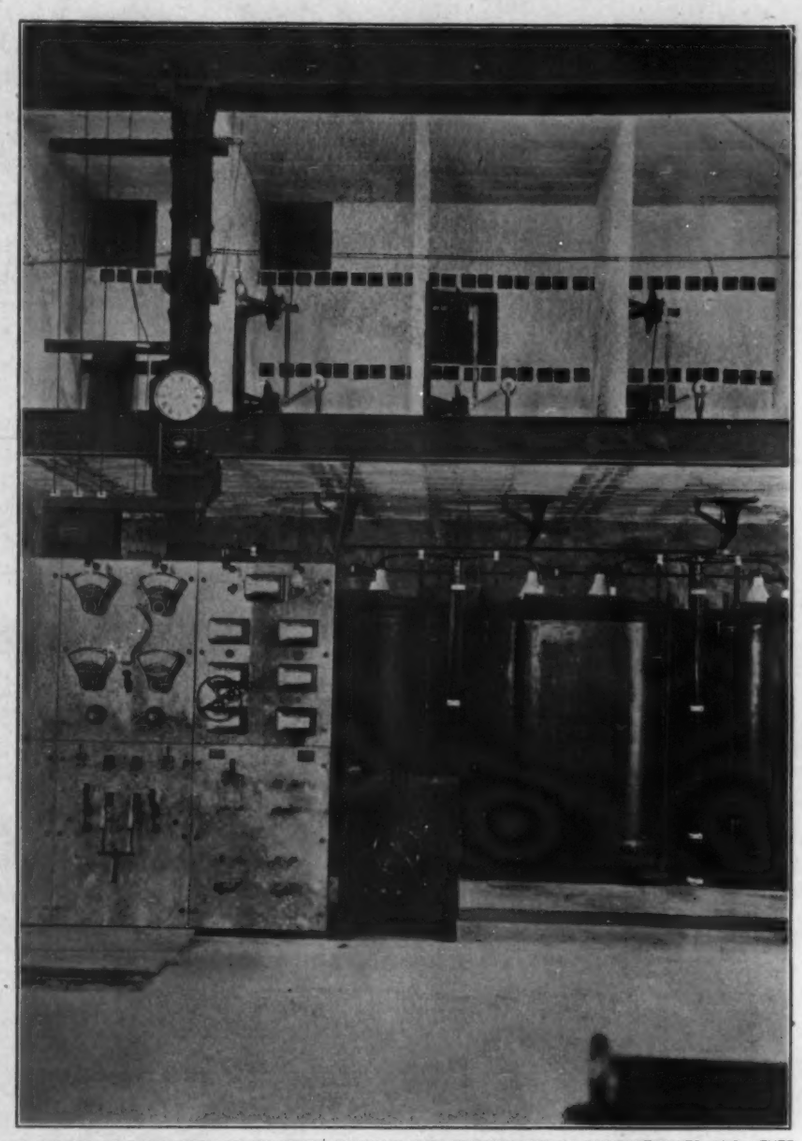
These pipe lines are provided with the latest type of six-inch air valves, air cock release valves and blow-offs and expansion joints, together with an eighteen-foot stand-pipe for each at the reservoir. The joint in the lap welded pipe is of the type designed by W. R. Echart



A PERSPECTIVE VIEW OF THE HIGH TENSION SWITCHING GALLERY OF THE DE SABLA POWER HOUSE

and originally installed at Electra, the only difference being that in the de Sabla plant a rubber core of a larger diameter is used. Pipe line No. 2 is anchored at every joint in the tunnel, while in the 1600 foot section of pipe line No. 1 there are thirty-three anchorages, one of which alone contains 100 tons of masonry. When it is known that the lower ends of these pipe lines must sustain a thrust of about 750 tons, the necessity for stalwart work in the direction of anchorages becomes apparent. Under normal conditions of load the nozzles discharge some 3000 miner's inches of water, the velocity of which in the pipe line is a little less than nine feet per second.

A bench blasted from the solid rock gives footing to the power house which consists of a steel and corrugated iron structure, sealed with corrugated iron. In the clear it measures 107 feet by fifty feet four inches, and along its peak is run a lighting and ventilating turret. In the center of the side of the building nearest the creek is built a small bay eight feet deep and thirty-seven feet long in which is contained the exciter sets. Two forty-ton traveling cranes of Cyclops manufacture stand the width of the entire building.



TRANSFORMER DISCONNECTING SWITCHES, SHOWING HIGH TENSION BUSBAR COMPARTMENTS AND LEVER MECHANISM

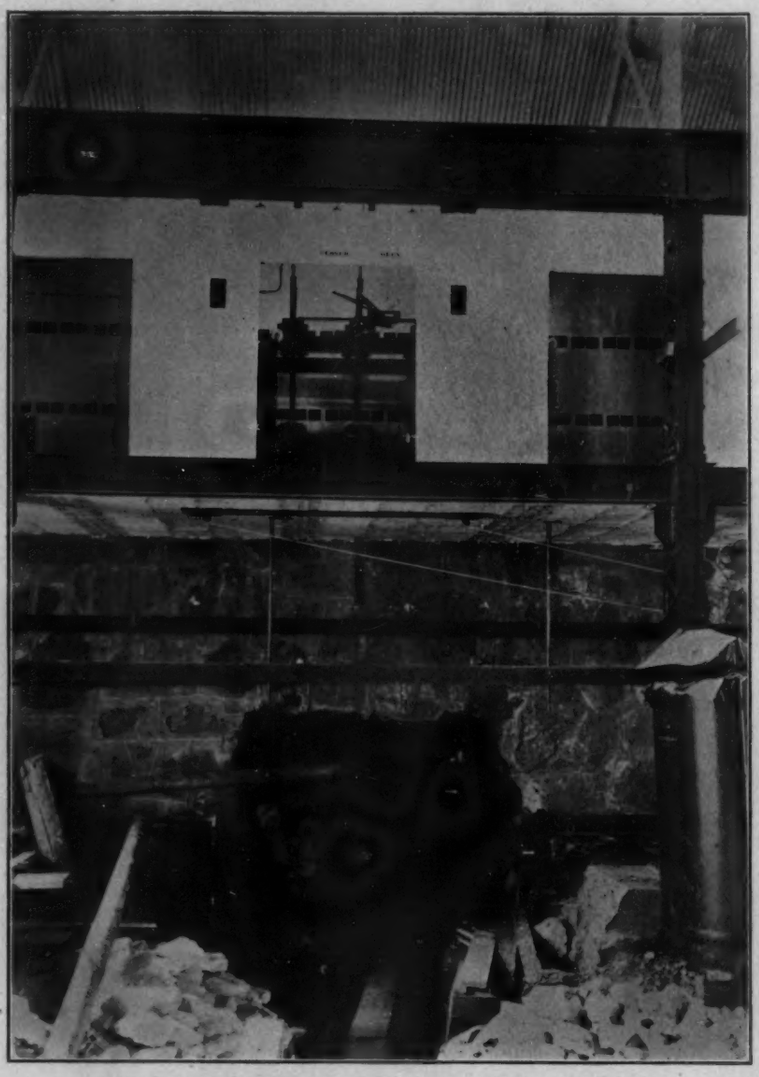
The plant was placed in service on October 22, 1903, with two 2000-kilowatt generators in operation, and on August 22nd of this year its third unit, consisting of a 5000-kilowatt generator, was placed in regular service.

The water wheels are of the Doble type and build, two of which have a capacity of 3500 horsepower each and the capacity of the third wheel unit being 7500 horsepower. In the wheel units first installed the buckets are mounted on a rolled steel disk having a diameter of ten feet ten inches, and this disk is supported on a hollow sixteen-inch shaft that in turn rests in bearings that are five feet five inches in length. These bearings are cooled by a water circulation and are supplied with oil under pressure. Each wheel of units Nos. 1 and 2 overhangs a concrete pit that is four feet wide and seven feet four inches deep, and the wheel casings stand eight feet six inches above the floor line. A single nozzle is used under each wheel. It is of the needle regulating and deflecting type, actuating by a Lombard type D governor. Water for the operation of these wheels is taken from pipe line No. 1, which separates into two branches for the respective wheels within the station. It enters the nozzles at a depth of twenty-inches below the floor line through a Doble piston gate valve with fourteen-inch openings. This gate valve is operated both ways hydraulically by turning a hand-wheel connected to a three-way valve. The water is applied to the wheels under an effective pressure of 1534 feet, the gauge standing at 666 pounds per square inch. The wheels, which are mounted direct on the end of the generator shaft, run at a speed of 240 revolutions per minute. A six-inch branch from the main pipe line at the curve carries water to the exciter wheels, each of which is controlled by a three-inch gate valve.

Lovers of the spectacular will ever find something to excite their admiration, if not awe, in the discharge of a five-inch stream of water under a net head of 1560 feet, giving a pressure of over one-third of a ton per square inch. This means that with a nozzle five inches in diameter, the static strain against this area is above seven tons, while the velocity of the stream is over 18,000 feet per second, or at the rate of three and one-half miles per

minute. An idea of the appearance of such a stream is given in the illustration on page 440. The visible portion of the jet as appears in the photograph has a length of about 150 feet before reaching the wall of rock on the opposite side of the creek, nevertheless the stream shows no influence from gravity, for it is as straight as though laid out with instruments of precision. The bombardment it gives the wall is simply terrific, and the atmosphere for a score of rods around is filled with spray that falls as rain, making merry cascades which flood the mountain sides, and as for the noise, it is a succession of ripping peals that deafen and strike with awe.

Pipe line No. 2 is used exclusively for the operation of the 5000-kilowatt unit, which is driven direct by a single Doble water wheel that under overload conditions delivers 5500 kilowatts at the switchboard by the single jet of water. Of the details of this wheel, however, more will be published in a special article which will be devoted to the subject in an early issue of THE JOURNAL.



STIRLING LINE DISCONNECTING SWITCHES AT THE DE SABLA POWER HOUSE

The exciter sets are of the Theberath combination type, consisting of a water wheel, an induction motor and a direct current generator mounted on a single shaft and first ussd with such pronounced success at Colgate. These sets are four in number, and each consists of a single eighteen-inch Doble water wheel, a seventy-five horsepower, three-phase, 2300-volt General Electric induction motor and a forty-five-kilowatt multipolar direct current General Electric generator wound to deliver sixty volts with no compounding. These three units of a set are direct coupled and run at a speed of 720 revolutions per minute. Each set is capable of exciting two 2000-kilowatt generators and the one 5000-kilowatt unit, and obviously in case of failure of the water wheel the induction motor which is always coupled in parallel with the generator busses will supply instantly ample power for the operation of the exciter.

Beyond the power house, along the foot of the bluff which rises precipitously as the background to the photograph reproduced on page 439 runs Indian Spring Ravine, which carries besides its own water that of several other springs of lesser note, together with such overflow as may come from the waste weir of the reservoir upon the mountain above. This ravine supplies ample water for cooling the transformers and generator and water wheel bearings and shafts, as well as affording fire protection. From this ravine is also filled a 10,000 gallon tank which, well housed, stands up on the hillside at an elevation of 180 feet above the power house, to which it is connected by about 650 feet of entrenched six-inch pipe. Not far from this tank is a corrugated iron building containing two iron tanks, one of a capacity of 1000 gallons for the storage of transformer oil, and the other, which holds 1500 gallons, for lubricating oil. These tanks are at an elevation of about seventy feet above the power house. All oil is handled either by gravity or by pumping. That from the bearings drains into a filtering reservoir outside the station at its lower corner, whence it is pumped back to the lubricating oil tank on the hill, and to empty a transformer case merely means to pump the oil back into the transformer main leading from the hill.

The statement has already been made that the de Sabla power house is of extreme simplicity, especially in the matter of its electrical equipment. Three generating units, a single panel switchboard for each, an exciter panel, a three panel main switchboard, the necessary transformers and the disconnecting switches up in the

fireproof gallery, constitute the entire electrical paraphernalia necessary for handling a normal load of 9000 kilowatts. As to details, each generator panel, placed convenient to its respective machine, carries two voltmeters, two ammeters, two indicating wattmeters, two recording wattmeters, all of the Thomson type, besides a synchronizing lamp and three-pole oil switch by means of which the low tension side of the set of transformers for the respective machine is thrown in parallel with it. The main switchboard carries three panels; the upper half of the first panel carries a synchronizing lamp, an ammeter, a voltmeter and a field ammeter for each of the two 2000-kilowatt generators, so as to give a reading for one phase of each machine. The lower half of this panel has four double-pole single-throw knife switches, by means of which the fields of either machine may be thrown on either exciter. This half panel also carries near the top two two-button plate pushes for running the Lombard governor on the respective water wheels either fast or slow, a result which is accomplished by means of a small electric motor that is one-geared to the valve stem of the governor. The panel also contains in its upper half hand wheels for controlling the field resistances of each 2000-kilowatt generator.

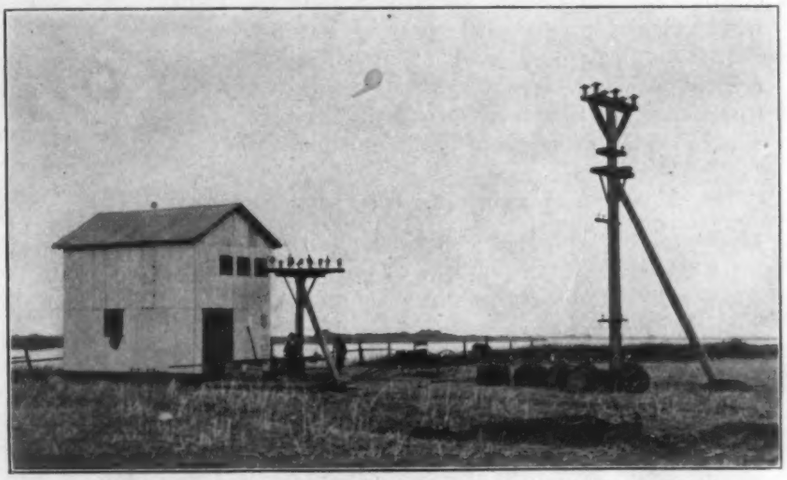
The second panel is essentially an exciter panel. Its upper half contains a Thomson static voltmeter and ammeter, as well as a rheostat for each exciter, and these, together with a recording voltmeter and a two-point switch therefor, completes its equipment. Below, the remaining half panel carries two small double-pole single-throw knife switches for the fields of the respective exciters, a large double-pole single-throw knife switch for paralleling the exciters, and a triple-pole oil switch for handling the 2300-volt three-phase current with which the respective induction motors of the exciter combination sets are always at least under excitation. No possible arrangement could be more simple nor more efficacious. Similar arrangements are provided on the third panel for the control of the 4000-kilowatt unit.

The transformer and high tension gallery section is to the writer's mind the most perfect piece of engineering construction to be found in California. It is contained in a bay which runs along the entire side of the building nearest the mountain. Its depth is eleven feet six inches. Its lower half, or that portion which is on the main floor of the station contains twelve raising transformers, each having a capacity of 840 kilowatts, with 2300 volts on the low tension sides, and wound to deliver either 44,000, 55,000 or 66,000 volts on the high tension side. They now give 66,000 volts or a little over. Immediately over the transformers is the high tension switching gallery, which is absolutely fireproof throughout, the floor being of steel I-beam and tiling construction flushed with concrete and all walls and ceilings being of hollow tiles. The views appearing on pages 440, 441 and 442 show the general appearance of this gallery during construction, and in explanation it should be stated that the gallery is divided into twelve compartments, each of which measures six feet two inches in width by eleven feet in length, the height being ten feet nine inches. Back of the switching compartments and running the entire length of the building are three separate parallel wire ways for the high tension busses. These wireways are each two feet square by a length of 107 feet, and are made of four-inch tiling on their front and back walls with separations of six-inch tiling. A single bus supported on standard Locke 60,000-volt insulators runs through the entire length of each, and to these busses the high sides of the respective transformers are cut in through individual single-pole air-break disconneeting switches which are controlled in gangs of threes by means of a system of levers actuated manually from the floor of the transformer section beneath. The busses reach the line through the intervention of a four-break high tension switch with a Stirling switch for emergency, as described by Mr. Baum, these switches occupying the compartment of the gallery nearest to the point where the transmission line leaves the building.

To complete this superficial description of the plant it is only necessary to state that the 2000-kilowatt units are counterparts of those of like capacity installed at Colgate, and which will be remembered are of the well known S.K.C. inductor type. The 5000-kilowatt unit is also of S.K.C. manufacture, but it is of a revolving field type. It is unique from the fact that the field coils are carried by two three-quarter-inch steel discs instead of the usual spider. These units deliver three-phase current at 2300 volts.—THE EDITOR.

F. G. BAUM ON TRANSMISSION AND CONTROL.

In 1900, at the general meeting of the American Institute of Electrical Engineers, I presented a paper giving "Some Constants for Transmission Lines," based on measurements made on several transmission lines—the longest that had been built up to that time. Since then I have followed very closely the progress of transmission



HIGH TENSION LINE SWITCHES IN CONSTRUCTION AT THE BLACK DIAMOND SUBSTATION

work, and in this paper I will give the practice and results on what is, and has been since 1900, the greatest transmission system in existence.

The system to which I refer is that of the California Gas and Electric Corporation, which has absorbed the Bay Counties Power Company, the Standard Electric Company of California, the Valley Counties Power Company, the Sacramento Electric, Gas and Railway Company, the Yuba Electric Power Company and the Nevada County Electric Power Company.

The system has continuously in operation about 700 miles of line at 50,000 volts, seventy miles at 40,000 volts and a great many miles at 23,000, 16,000, 10,000 and 5000 volts. The high voltage lines extend from the Sierra Nevada Mountains of California to the Bay of San Francisco, and are thus exposed to all sorts and conditions of weather. In a short time some of these lines will be operating at 60,000 volts. The longest distance to which power is regularly transmitted is 200 miles, most of the power being transmitted 150 miles. The amount of power available on the system is 43,650 kilowatts, and this will soon be increased by the addition of two 5000-kilowatt generators at Electra. Owing to the large day motor load the peak on the system is not above 25 per cent. of the average load.

In this paper I will give as briefly as possible some simple methods of line calculation, and deal with the methods of controlling the power at the high voltages.

PART I—LINE CALCULATIONS.

The theory of the transmission of electrical energy over commercial distances is quite simple, and at present better understood than formerly, but there is still more guess work than there should be. As all long transmission work is three-phase, this is the only system which need be considered.

1. Circuits—In making three-phase line calculations, it is generally simplest to consider one leg of the system, assuming it to have neutral return with no resistance or reactance. Generally, high voltage systems are operated with grounded neutral, but whether the neutral is grounded or not we may consider the quantities between one line wire and a real or assumed neutral. The wires will be assumed as arranged on the wires of a triangle.

2. Charging or Capacity Current—In the paper referred to above, I showed that the line capacity of a three-phase line is star connected, the capacity of each wire to neutral being given by the equation—

$$C=\frac{1}{2\log_e\left(\frac{d}{r}\right)}$$

in electrostatic units per centimeter of circuit, d and r being taken in the same units, d is the distance between wires and r their radius. The charging current per mile is $C=\frac{.0776}{2\log_{10}\left(\frac{d}{r}\right)}$ per mile

The charging current per wire at a voltage E between wires and frequency f is

$$\text{Charging current per mile of wire}=\frac{E\,C\,2\pi f}{\sqrt{3}\;10^6}$$

(The charging current of a three-phase line is $\frac{2}{\sqrt{3}}$ times, or 15.5 per cent., greater than the charging current of a single-phase line with the same voltage and distance between wires).

In Curve II, Figure 1, is given the charging current in amperes per mile per wire with 10,000 volts between wires, the frequency being 60 cycles. From this curve the charging current for any line at any voltage or frequency may be calculated in a very few moments. Add 2 per cent. to the value obtained for a No. 2–0 wire, 4 per cent. for No. 4–0, etc., and subtract 2 per cent. for a No. 1 wire, 4 per cent. for a No. 2, etc. This rule practically holds for a half-dozen sizes on either side of No. 0, for which the curve is calculated. This will include all sizes commonly used.

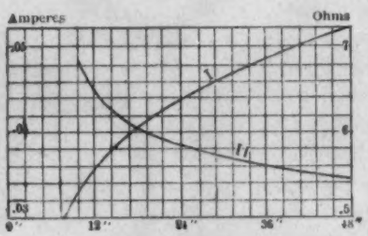


FIGURE 1. INDUCTANCE AND CHARGING CURRENT, NO. 0 WIRE

For wire three-quarters of an inch in diameter, spaced twelve feet, the charging current is 0.0331 amperes per mile with 10,000 volts between wires. This is 4 per cent. less than for No. 0 wire spaced forty-eight inches. Curve I gives the inductance per mile per wire at 60 periods per second. For single-phase or two-phase, multiply by 1.15. For single-phase or two-phase, multiply by 0.87.

3. Reactance Pressure—The self-inductance in C.G.S. units per centimeter may be calculated from the expression—

$$1=2\left[\log_e\left(\frac{d}{r}\right)+\frac{1}{4}\right];$$

and the self-induction in henrys per mile per wire from the expression—

$$L=\text{henrys per mile}=0.000322\ [2.303\log\left(\frac{d}{r}\right)+.25].$$

The percentage reactance pressure for a given current, I, at a given frequency, f, may be calculated from the expression, X being the length of line in miles—

$$\frac{X\,L\,2\pi f\,I}{\frac{E}{\sqrt{3}}}+100$$

We see that in the formula for the reactance pressure we always have the ratio of the voltage between wires and length of line in miles. Assuming a given number of amperes flowing in the line, say 100, we may construct a curve between the percentage reactance pressure and the ratio of volts to length of line in miles $=E/X$. This has been done in Figure 2, from which the percentage reactance pressure for any given case may be quickly determined. Curves are given for twelve-inches, twenty-four inches and forty-eight inches between the wires. The results are given for a three-phase line with 100 amperes per wire, frequency 60 periods per second, size of wire, No. 0, B. & S. These curves bring out in a striking way the effect of reactance in the line, and the difficulties of regulation in long lines. For any other current, multiply the percentage reactance pressure by $I/100$; for any other frequency multiply by $f/60$. For

a single-phase, or two-phase system, multiply the percentage reactance pressure by 1.15. For No. 1 wire multiply the percentage reactance pressure by 1.02; for No. 2 wire, multiply by 1.04, etc. A great deal of labor may be saved by becoming familiar with the use of Figure 2.

Example—Voltage between wires—50,000; distance between wires—24 inches; length of line, 100 miles.

Then $E/L = \frac{50,000}{100}$, and from the curve, Figure 2, we find the percentage reactance pressure for 100 amperes =22.1. The reactance pressure in volts per loop will be

$.221 \times 50,000 = 11,050$, or $\frac{11,050}{\sqrt{3}} = 6390$ volts per wire.

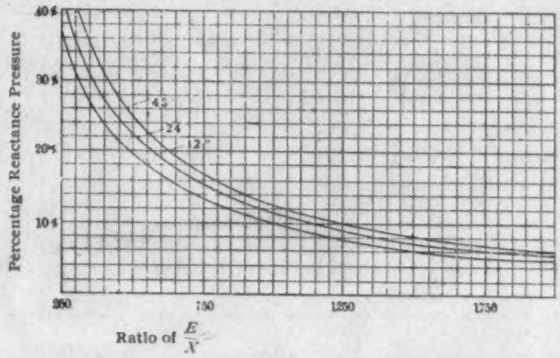


FIGURE 2. CURVE FOR OBTAINING PERCENTAGE REACTANCE PRESSURE

For wires three-quarters inches in diameter, spaced twelve feet, add 4 per cent. to curve for forty-eight-inch spacing and No. 0 wire.

These curves furnish a method of quickly determining the percentage reactance pressure. For each size larger than No. 0 we subtract 2 per cent. from the values given.

Rise in Pressure Due to Charging Current—It was shown in the paper first referred to that for all practical purposes the capacity of the line may be considered concentrated at the center of the line. This being the case, the rise in pressure is due to charging current flowing over the line reactance from the generator to the center of the line, and hence may be calculated by the expression

$$\text{rise in pressure} = \frac{x\,L\,2\,\pi\,f}{2}(\text{charging current})$$

and the percentage rise in pressure will be this value divided by the line pressure and multiplied by 100. As the charging current varies as the line pressure the percentage rise in pressure is, therefore, independent of the line pressure.

4. Regulation of Transmission System—Of prime importance is good regulation, it being impossible to give satisfactory service unless the ordinary fluctuations of voltage can be kept within 5 per cent. This is not difficult with large induction motors, if the motors carry a fairly steady load. By large motors I mean from 500 to 1000 horsepower. Smaller motors may have varying loads and not cause any noticeable fluctuations with lines 150 miles long operating at 50,000 to 60,000 volts. The most difficult load to handle is a large electric railway load having no storage battery. The only way to handle such a load successfully is to use automatically compound synchronous motors. In this way street railway loads of any size may be handled by the same line supplying the lighting.

Since the method of calculating the regulation of a transmission system, as ordinarily carried out, is exceedingly laborious, a method* is here given which is very simple.

Taking the lost pressure over the system as a whole, we are always concerned with three pressures in any case: First, the receiver pressure; second, the lost pressure over the line; third, the pressure delivered to the line. The lost pressure is made up, in any practical case, of the resistance pressure and the reactance pressure. When, as is generally the case, we have receiver loads of different power factors, we get simpler results if we consider the total receiver current divided into two parts, one the power component and the other the wattless component of the receiver current, and regard each as flowing separately over the line.

If I is the total receiver current and θ the angle of lag of the receiver current behind the receiver pressure, the power component of the receiver current is $I \cos \theta$, and the wattless component is $I \sin \theta$ ($\cos \theta$ is the power factor of the receiver circuit; for a non-inductive load $\cos = 1$; and $\sin \theta = 0$). Let $E = oa$, Figure 3 represents the receiver pressure. The pressure consumed by the line resistance and reactance due to the power component of the load current is $I \cos \theta \sqrt{R^2+(L\omega)^2}$, in which R is the resistance and $L\omega$ is the reactance of the line. In Figure 3,

$$ab = I \cos \theta\, R$$
$$bc = I \cos \theta\, L\omega$$
$$ac = I \cos \theta \sqrt{R^2+L\omega^2},$$

ab is 8 per cent. of the receiver pressure; that is, the I^2R loss in line is 8 per cent. at full inductive load.

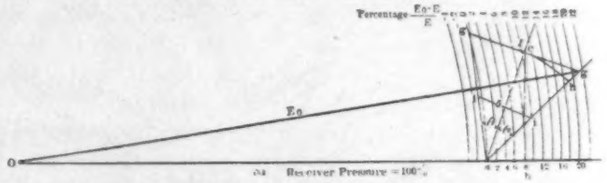


FIGURE 3. SHOWING METHOD OF DETERMINING REGULATION

In Figure 3, ac represents, then, in magnitude and direction, the pressure consumed over the line by the power component of the receiver current. If for a lagging current we make the angle $cag = \theta$ (θ is the angle by which the receiver current lags behind the receiver pressure) and the angle $acg = 90°$, then

$$cg = I \sin \theta \sqrt{R^2+(L\omega)^2},$$

as can be proved by simple geometry. That is to say cg represents in magnitude and direction the pressure consumed over the line by the wattless component of the

*"A Simple Diagram Showing the Regulation of a Transmission System of Any Load and Any Power Factor," by F. G. Baum, *Electrical World and Engineer*, May 18, 1901; also "An Alternating Current Calculating Device," by F. G. Baum.

receiver current. (If the receiver current leads the receiver pressure by the angle θ, the cg' is equal to the pressure consumed by the wattless component of the receiver current.)

It should be particularly noticed that the pressure consumed by the wattless current is at right angles to that consumed by the energy current. Notice also that ac is proportional to the power current, and cg to the wattless current. The true direction of the power current is along E, and the wattless current at right angles to E—downward for lagging, upward for leading current. The line ag therefore represents in magnitude and direction the pressure consumed over the line by the total receiver current. Hence og represents Eb, the pressure delivered to the line, in magnitude and direction. ac represents the pressure consumed by full load non-inductive current. Then $ac/2$ will represent half load on the line, etc. For half load, and the same angle as before, E is given by oi. Through c, with a as center, a circular arc has been drawn At full load current, and a power factor corresponding to the angle θ, the value of E is given by oh.

With θ as center, circular arcs have been drawn through a, 2, 4, etc. The radial distance between two successive arcs is 2 per cent. of the receiver pressure. We see, as shown by the point c, that the regulation of this system for full non-inductive load is 11 per cent.; that is, the generator pressure must be 11 per cent. higher than the receiver. At full kilowatt load, at a power factor corresponding to the angle θ, the regulation is 21 per cent., as shown by the point g; at full kilovolt ampere load; that is, for the same current as before delivered at the same power factor, the regulation is 19 per cent., as shown by the point h.

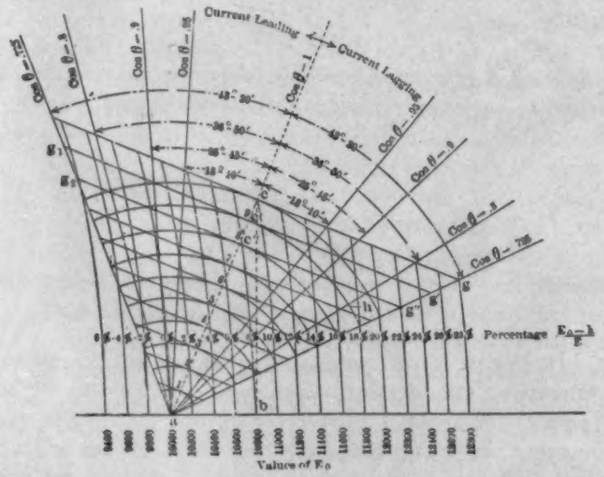


FIGURE 4. SHOWING REGULATION OF FIFTEEN-MILE TRANSMISSION SYSTEM

In Figure 4 is shown a case corresponding to a fifteen-mile transmission line, for a receiver pressure equal to 10,000 volts, transmitting 3000 kilowatts (the point o is not shown); ac, which represents full load, has been divided into ten equal parts, corresponding to 0.1, 0.2, etc., at full load. Through points marked 0.1, 0.2, etc., lines have been drawn at right angles to ac. Radial lines making angles corresponding to cos θ — 0.95, cos — 0.9, etc., for lagging and leading currents, having been drawn from a. Circular arcs, with the point a as center, have also been drawn through points along ac marked 0.1, 0.2, etc. The regulation for any load and any power factor may be determined from the figure.

For example, to find the regulation at full load at 0.8 power factor, go along ac to $c' = 0.9$, then along $c'g'$ to

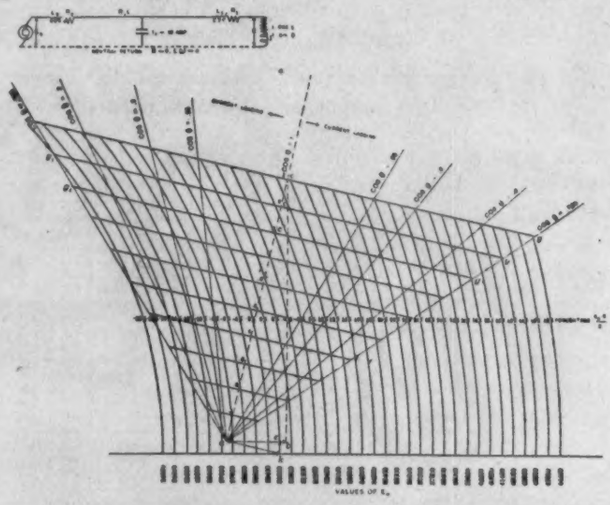


FIGURE 5. SHOWING REGULATION OF 150-MILE TRANSMISSION SYSTEM

the intersection with the line cos $\theta = 0.8$. The regulation is seen to be about 21½ per cent. For 0.9 full load current and the same power factor, the regulation is 17 per cent., as shown by the point h. It is seen that for any given case it is only necessary to determine the triangle abc; the remainder of the figure is drawn mechanically.

Figure 5 shows the regulation of a 150-mile, 60 periods per second, three-phase line for any load and any power factor, with 30,000 volts between neutral and line wire, giving 51,960 volts between wires. The power transmitted is 3000 kilowatts per leg, or a total of 9000 kilowatts The small triangle Kea shows the rise in pressure due to the charging current. The regulation of the line for any load at any power factor is clearly shown. At no load, with 27,500 at generator, we get 30,000, or full voltage, at receiver, or a rise in pressure of 9 per cent. The effect of a synchronous motor load of any charaeter may be determined from the figure.

5. Electrical Surges—We cannot avoid an occasional short circuit on the high voltage line. These shorts cause a heavy current to flow over the line, and the breaking of this current sets up surges which cause a rise in voltage that may be two to three times the normal operating voltage. The subject has been discussed by C. P. Steinmetz, Dr. A. E. Kennelly and P. H. Thomas. A simple method is here given, the matter having been first presented at the annual meeting of the Pacific Coast Electric Transmission Association, in 1892.

The subject is an interesting one to us, as we have all seen lightning arresters fused on account of the sudden opening of a circuit. I shall attempt to put the matter as briefly as possible, and in such a form that the rise in

potential which we may get under the worst conditions may be easily and quickly determined. The most important case of opening a short circuit under load will be discussed.

Opening a Line Under Load or Short Circuit—Let us consider the case of a long line with a receiver load concentrated at the end. The line capacity will be assumed equivalent to a single capacity at the center of the line. We will consider one leg of a three-phase system. The self-induction of one wire from the generator to the center of the line, that is, up to the assumed location of the capacity, is L, and the capacity of the entire line as a condenser is C (C being the capacity between one line wire and neutral). A current, I, flows over the line and is suddenly interrupted. As is well known, the energy stored up in the magnetic field (due to the current I), between the generator and the center of line is $LI^2/2$. If the current is suddenly interrupted, this energy must flow into the line condenser, since there is no other outlet. (It shonld be noticed that when the receiver is opened, the line condenser is in series with one-half the line and the generator.)

If V is the resulting potential across the line condenser the energy stored up in the condenser is $CV^2/2$. But this is the same amount of energy which was previously stored in the magnetic field, neglecting the small loss due to the current flowing over the line resistance in flowing over the line into the condenser. Therefore,

$$LI^2/2 = CV^2/2 \text{ or}$$

$$I = V\sqrt{C/L} = VC\frac{1}{\sqrt{LC}} \qquad (1)$$

The current produced in a condenser of capacity C by an electromotive force having a frequency f is equal to $E\,C\,2f$.

Comparing terms with (1) we see that $\frac{1}{\sqrt{LC}} = 2\pi f$, in which f is the frequency of the current in the condenser. Equation (1) may therefore be written

$$I = VC\,2\pi f \qquad (2)$$

in which f is the natural periodicity of the line. What really happens then when we interrupt the current I, is that the same current, having its natural outlet cut off, flows into the line condenser and charges the line. But the line condenser cannot remain charged, and, therefore, the condenser discharges again into the line self-induction, and the energy again is in the form of magnetic energy. The magnetic field, then, again breaks down, giving up its energy to the capacity and the whole cycle is gone over again and again, until the resistance of the line consumes the energy originally stored in the line self-induction. The frequency of the give-and-take of energy between the capacity and line self-induction is determined by the natural periodicity of the circuit f. The frequency f in the equation (2) is therefore the frequency of the current I, after this current has been interrupted at the receiver. If the current is working normally at a frequency f', the current I changes from a frequency f' to a current of frequency f, that is, from the normal impressed period to the natural period of the circuit.

The natural periodicity of a circuit may be easily found from the equation

$$2\pi f = 1/\sqrt{LC}$$

$$f = 1/2\pi\sqrt{LC} \qquad (3)$$

For a three-phase transmission line we may take the self-induction for one-half the line, for one wire, as .08 henrys per hundred miles, or $L = .08\ D$, D being the length of line in hundred miles. C may be taken as two microfards per hundred miles, or $C = 2/10^6$ farads. Substituting for C and L in equation (3), gives us approximately

$$f = 400/D. \qquad (4)$$

This frequency will not differ much for different distances between wires, because an increase in the distance will increase L and decrease C, the product remaining nearly the same. The same is true for different sizes of wire. That is, a line 100 miles long has a natural periodicity of about 400; a 200 mile line a periodicity of 200, etc. If we are operating normally at 60 cycles, a 200-mile line has a natural periodicity of little more than three times the frequency of operation.

From (2) we get the potential across the line condenser due to interrupting the current I equal to

$$V = I/C\,2\pi f. \qquad (5)$$

Substituting for C the value $2\ D/10^6$, and for f the value $400/D$, we get the simple equation

$$V = 200\ I \text{ (approximately)}. \qquad (6)$$

That is, the rise in potential due to the surging current is, as a first approximation, independent of the length of the line and equal to 200 times the interrupted current in amperes. If I is equal to 100 amperes (141 amperes maximum), and the current is interrupted when it has its maximum value, then

$$V = 200 \times 100\sqrt{2} = 28{,}200 \text{ volts.}$$

Interrupting 200 amperes would give us double this rise. This electromotive force will be superimposed on the line electromotive force, so the maximum strain possible for any interrupted current is

$$\text{Maximum strain} = E\sqrt{2} + 200\ I\sqrt{2}.$$

E is the voltage between line wires and neutral, and I is the current in amperes interrupted. It has been frequently noticed that a line having been short circuited, and the short circuit broken, the arc will frequently re-establish itself or a new short start at some other place between points across which the line voltage could not jump. The superposition of the oscillating electromotive force due to the removal of the short circuit to the line electromotive force is no doubt the explanation. We have assumed that the current is instantly interrupted. An arc will always be formed which will reduced the rise in potential.

On account of the inductive drop over the line, it is very probable that the current to be transmitted over one wire of a long distance transmission (150 to 200 miles) must be limited to about 100 amperes, unless the frequency is reduced below sixty. One hundred amperes, at sixty

cycles, transmitted over a line 200 miles long, gives us an inductive drop of about 50 per cent., with 50,000 volts between wires. The generators will probably deliver four times full load current as a maximum on short circuit. A short circuit in the center of the line would, therefore, give us about twice full load current, so that the maximum rise in potential due to the interruption of the short circuit would be about 56,000 volts. If the line is operating at 30,000 volts (equals 30,000 $\sqrt{2}$ maximum) between neutral and line wire, the strain would be a little more than twice the neutral. Under certain conditions a greater rise may take place.

It seems, therefore, that there is a limit to the amount of power that can be transmitted over a line, which limit is fixed by the insulation factor against the surge voltage. If we reduce the frequency of the transmitted current to 25 or 30 cycles, so that we could transmit, say, in the neighborhood of 5000 amperes over a single line without having excessive reactive drop, then we must insulate for the normal working pressure, say 30,000 plus the surge voltage, which in this case would mean insulation to withstand a voltage of 185,000 volts, as shown below—

$$\begin{aligned} \text{Strain} &= 30{,}000\sqrt{2} + 200 \times 500\sqrt{2} \\ &= 130{,}000\sqrt{2} \text{ volts} \\ &= 185{,}000 \text{ volts.} \end{aligned}$$

In other words, we must make our insulators and transformers stand a repeated momentary pressure of about 200,000 volts.

To transmit the same power at 60,000 volts, reducing the current transmitted to 250 amperes, would cause a smaller total strain due to the surge. The enormous strains introduced when we come to transmit from 25,000 to 100,000 kilowatts over a single line will require extraordinary insulation against rupture due to the line surges.

In the above we have assumed a long trunk line with a receiver at the end. When the receiver current is interrupted the line current is forced into the condenser. On our long lines, however, we usually have loads distributed along the entire length, and if there is a load on

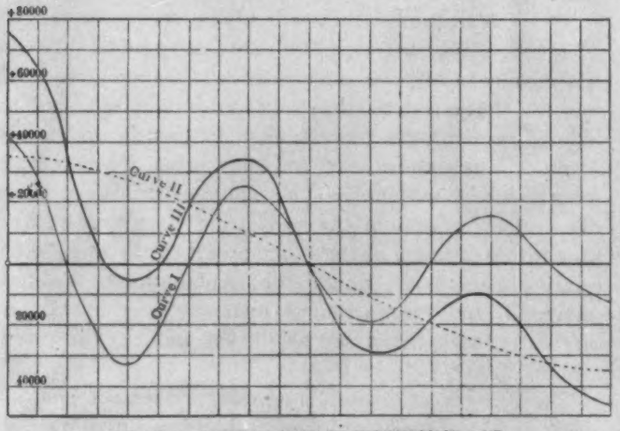


FIGURE 6. SURGE VOLTAGE ON TRANSMISSION LINE

at different points the line discharges a portion of its energy into the local distributing circuits, and the rise in potential is therefore limited.

The amount of energy stored in one-half of a 100-mile line is quite small, yet it may do considerable damage. For 200 amperes it is

$$L I^2/2 = \frac{.08\ (200)^2}{2} = 1600 \text{ joules;}$$

that is. 1600 watts for one second.

We see from the above that the most dangerous condition is brought about when we suddenly open a short circuit. Curve I, in Figure 6, shows the calculated oscillating potential due to interrupting 150 amperes on a line about 130 miles long. Curve II shows the generator potential (60 cycles) and Curve III the resultant line potential. The line voltage is 25,000 between neutral and live wire. The current is interrupted so as to produce a maximum rise of potential.

The resultant potential, we see, is very different from the impressed generator pressure. If we continue to lengthen our lines until the natural periodicity of the circuit becomes nearly equal to the impressed periodicity, it is very probable that we will have some new problems to solve. It may be that this will prove the determining factor which will limit the distance of transmission.

PART II—HIGH POTENTIAL CONTROL.

1. Insulators—We have on our lines practically every type of insulator manufactured. We have glass insulators, porcelain insulators and combinations of porcelain and glass having from one to four parts. In the mountains and away from the fog, a seven-inch glass does very well on 40,000 volts, but to go from 40,000 to 60,000 requires that the insulator be increased more than the proportionate increase in voltage. The insulator shown in Figure 7 is used up to 50,000 volts, but at this voltage it gives trouble in the fog districts and during wet weather. Insulators of the types shown in Figures 8 and 9 give very good results and are probably as good as can be obtained at present. Figure 9 has been designed by the engineers of the California Gas and Electric Corporation.

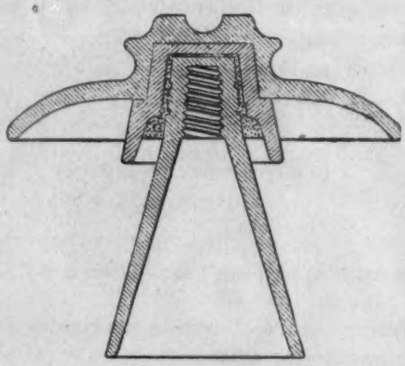


FIGURE 7. FORTY-THOUSAND-VOLT, ELEVEN-INCH, PORCELAIN INSULATOR

As the time will probably come when 100,000 volts will be as common as 10,000 is today, we have not yet reached the limit of development in line insulation. In testing

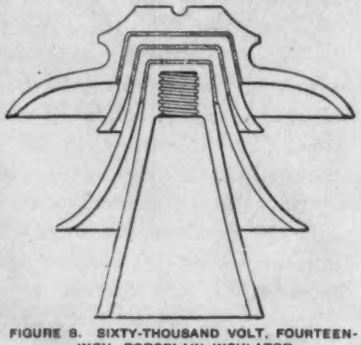


FIGURE 8. SIXTY-THOUSAND VOLT, FOURTEEN-INCH, PORCELAIN INSULATOR

the insulators, each part is subjected to more than the normal voltage from line to ground. The top is generally tested to 55,000 volts, the center to 45,000 and the middle petticoats to 40,000 volts. The test is made with salt water as electrodes.

2. Pins—We are using iron pins on all our new work, and believe the idea of depending on the pin for insulation is wrong. Place the strain where it belongs—on the

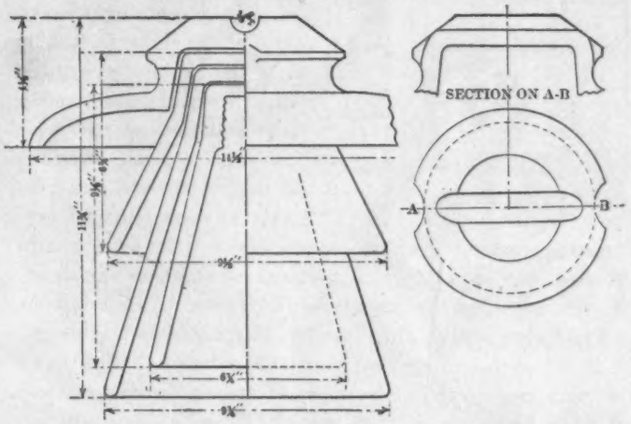


FIGURE 9. SIXTY-THOUSAND-VOLT, FOURTEEN-INCH, PORCELAIN INSULATOR

insulator. We are making our pins of pipe drawn down at one end. The pins are galvanized and a lead thread then cast to fit the insulator.

3. General Line Construction—We are constructing our 60,000-volt lines with a six-foot spread, the wires being on the corners of a triangle. On our late work we are using tall poles and spreading about double the distance ordinarily used. In the mountains, where we can take advantage of the hills and ravines, we use long spans, having some aluminum spans of 1000 to 1800 feet in length.

A tower construction using a span of about 500 feet would make an ideal line, and a line not much more expensive and much easier to care for than the ordinary pole line.

Our method of entering buildings is through a piece of plate glass about twenty-four inches square, having a hole about three inches in diameter through which the wire passes. The glass is held by a simple wood frame. This construction is more satisfactory than the old method of passing through terra cotta pipe.

4. Line Operation—The lines are operated by keeping men at important points who patrol the lines from one to three times a week, depending on the condition of the line, these men being ready at all times to go out in caee of emergency.

Our line troubles have been due to a few weak insulators; in some localities we have a good many insulators shot off. Some of our unexpected causes of trouble have been cranes or geese flying into the line; cats climbing up on the poles; green hay carried by wind dropped on the line; an engine starting up under the lines; a long-tailed rat crossing temporary busbars.

5. Trensformers—Our transformers have given us very little trouble and are really the most satisfactory part of the system. High primary insulation and care in the handling of the oil to keep it free from dirt and moisture are of prime importance. The windings should be dried out before adding the oil.

That the presence of the oil does not add to the fire risk was amply demonstrated by a fire at the Colgate station in March. 1903. The transformers were in the hottest part of the fire and were damaged but little, the oil acting as a protection to the winding. The transformers were not responsible for the fire, as was reported at the time.

On test, the primary of each transformer should stand a test about equal to double the star voltage for which the transformer is designed. That is, a transformer which is to be connected 30,000 star, giving 51,960 volts

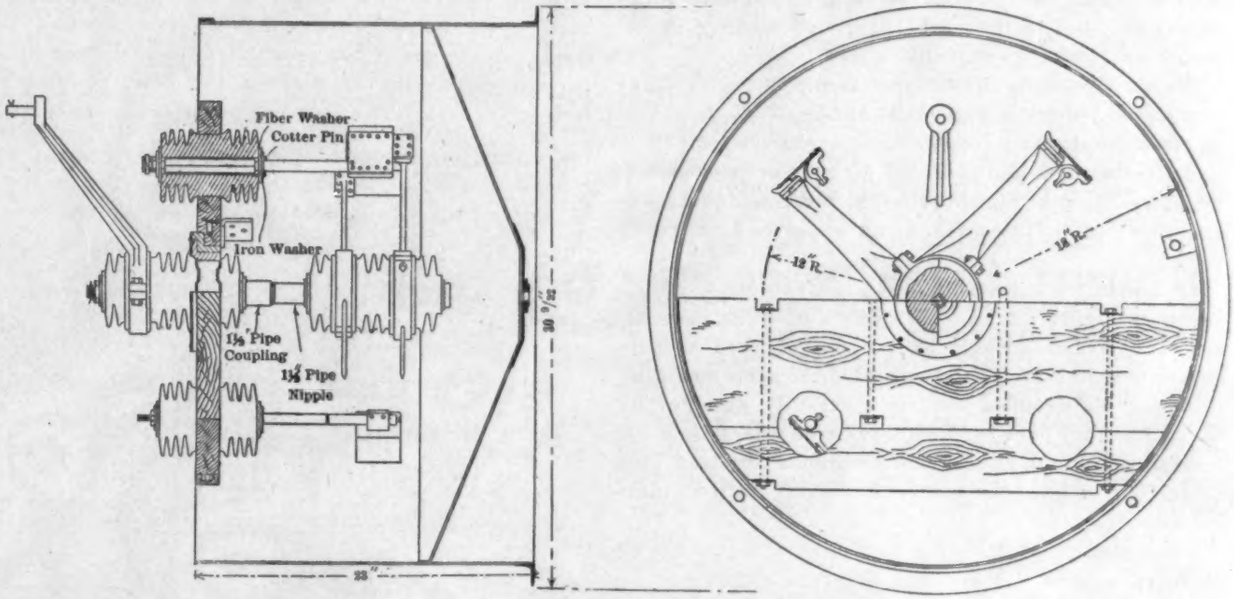


FIGURE 10. SIXTY-THOUSAND-VOLT, FOUR-BREAK, OIL SWITCH

line pressure, should stand an insulation test of about 100,000. Some manufacturers put on a test voltage from two to three times the transformer voltage. Less than two and one-half is not a good test.

6. Switches—We find it convenient to use two types of switches to handle the electrical energy—the oil type

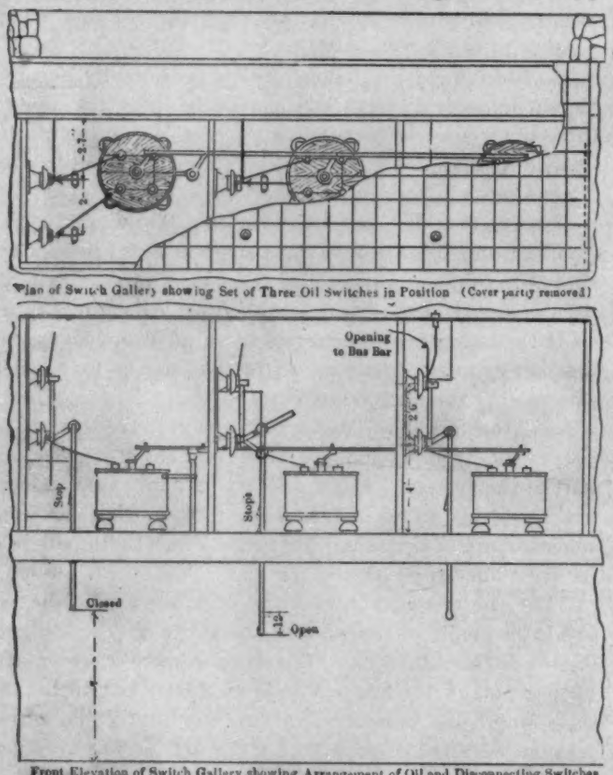

Plan of Switch Gallery showing Set of Three Oil Switches in Position (Cover partly removed)
Opening to Bus Bar
Stop
Stop
Closed
Open
Front Elevation of Switch Gallery showing Arrangement of Oil and Disconnecting Switches (Front of Switch Rooms removed)

FIGURE 11. SIXTY-THOUSAND-VOLT OIL SWITCH IN PLACE

and the air type. That the oil type switch is the only one that will stand heavy duty has been amply demonstrated. As it has not been possible to purchase satisfactory switches in the market, I have designed a line of switches for our high potential work.

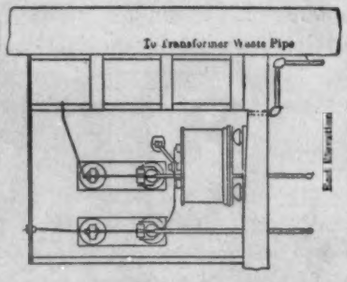
We are now using the switches shown in Figure 10 at our power houses, designed to handle from 10,000 to 40,000 kilowatts at 50,000 or 60,000 volts. Each pole is in a separate tank and mounted in a fireproof compartment, as shown in Figure 11. The three poles are operated together. The switch, as shown, gives four breaks per leg.

On less important work we use the two-break switch shown in Figure 12. This is a very simple and inexpensive design, but answers all purposes as well as more elaborate switches. Switches having the same operating principle, but mounted designed differently, designed by R. H. Sterling, have been in service on the system for several years and have given very good results. This switch will open 10,000 kilowatts at 60,000 volts on short circuit.

Disconnecting switches are used on each side of the oil switches, as shown in Figure 11, that the switch may be examined and repaired with line and busbars in service.

For connecting transformers to busbars we use three-pole disconnecting switch, as shown in Figure 13. This is a simple design and works perfectly. Figure 14 gives a large view of the switch. As shown by Figures 11 and 13, each busbarr is run in a separate duct.

For an outdoor switch for substations and branch lines where the load does not exceed about 1000 kilowatts, we use the switch shown in Figure 15. The switch is mounted so that the three poles open simultaneously from a distant point.



Electrically all switches on the system are liable to have the same duty to perform in case of a short circuit beyond the switch, and some make it a practice to have all switches the same, depending upon the power behind them. While this is correct electrically, the liability of trouble is slight and it is better to assume that you will occasionally burn up an inexpensive switch by trying to open on a short than it is to burn up all your money in the beginning by installating every switch of a high capacity, and at great expense.

7. Lightning Arresters—For lightning protection we have decided to pin our faith to the horn arresters, these made with single or double air gap. This simple device with good transformer and line insulation has given good results. Lightning is very often blamed for troubles that are primarily due to insufficient insulation and ignorance.

8. General Arrangement of Power House—Figure 16 shows my idea of the general arrangements of a power house in the mountains. Our high head power stations are usually in deep canyons, and the logical method of construction, it seems to me, is to take advantage of the natural slope, as shown. We go from the generator through the 2300-volt switch located under the floor, then to the transformers, which are located on a lower level than the power house, with the floor left open so the operator can see the transformers and note the temperature on the dial. The floor level of the transformer room

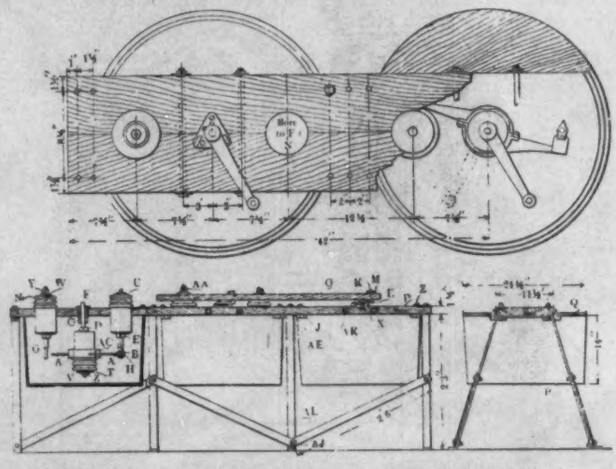
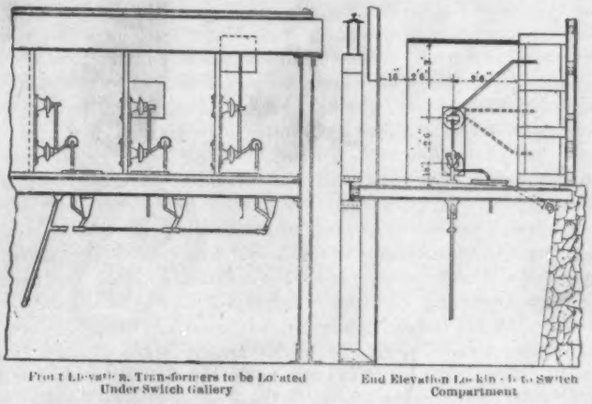


FIGURE 12. SIXTY-THOUSAND-VOLT, TWO-BREAK, OIL SWITCH

may be below the high water line. From the transformers we come up to the disconnecting switches, then through the oil switches to a second disconnecting switch to line. Locating the transformers in this way puts them in view of the operator, the practice of constructing a



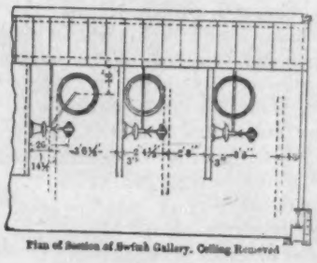


FIGURE 13. SIXTY-THOUSAND-VOLT DISCONNECTING SWITCH

separate transformer room at a distance being wrong, in my opinion.

For fire-walls we have the tail races between banks. I have yet to see a transformer in trouble that could not be pulled off before anything more than an injury to the coils had resulted. The switches being located in fireproof rooms makes it impossible for fire to spread in any way. The arrangement given, it is believed, has a great many advantages, being compact, safe, easily operated and economical.

Our general practice is to generate at 2300 volts and step up to the line voltage, the primary of transformers being connected star with grounded neutral. I have come to believe the grounding of the neutral to have more advantages than disadvantages. We take advantage of the grounded neutral and very often install a single transformer in a substation, one side going to line, the other to ground; where the load is larger but does not warrant three transformers we put in two using two legs of the primary and open delta on the secondary. We are not bothered by any unbalancing of load at the power houses.

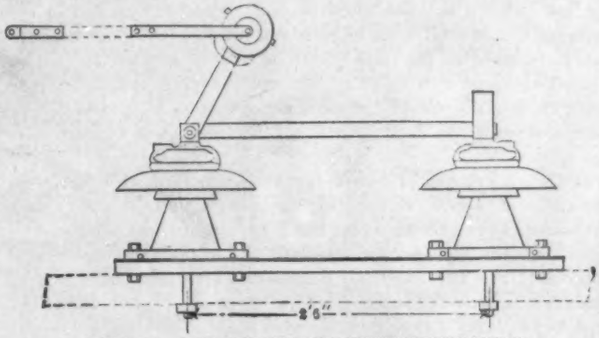


FIGURE 14. SIXTY-THOUSAND-VOLT DISCONNECTING SWITCH

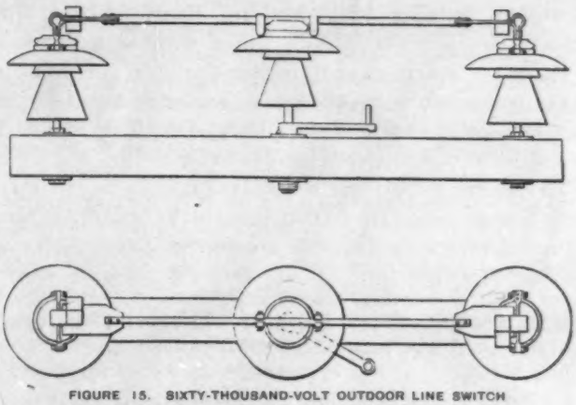


FIGURE 15. SIXTY-THOUSAND-VOLT OUTDOOR LINE SWITCH

At the power houses we use no fuses or circuit breakers, preferring to hang on to a short rather than take chances of pulling the line off for every slight interruption. At substations the transformers are generally fused.

The size of our units has gradually increased from 300 kilowatts, installed in 1897, to our present 5000-kilowatt units. The 5000-kilowatt unit is of the two-bearing type

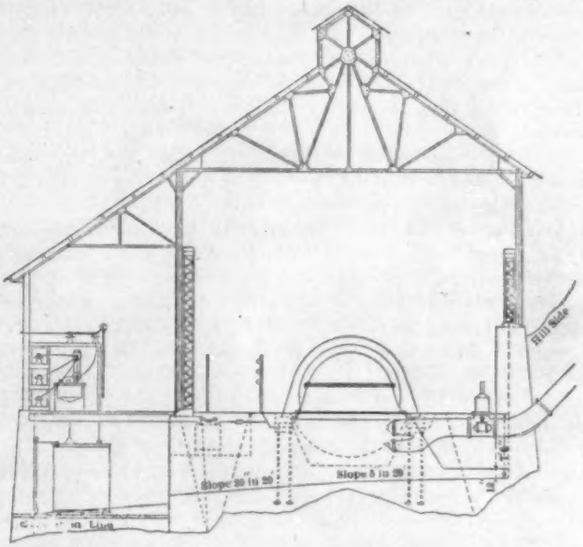


FIGURE 16. SHOWING GENERAL ARRANGEMENT OF POWER HOUSE

with overhanging water wheel. With this type we can put 20,000 kilowatts in a building 100 feet long by fifty feet.

9. Line Voltage—Regarding the proper voltage to be used for transmission, this will depend on conditions, mainly on the length of line. From fifty miles up it will be generally economical to use as high a line voltage as is practicable. At the present time 60,000 volts can be safely handled, and 80,000 volts is not out of reach in certain localities by those experienced; and judging the future by the past, we may expect to reach 100,000 operating voltage in a few years.

Our greatest trouble is occasioned by the fog. This in districts near the ocean or bay settles on the insulators and reduces the insulation to such an extent that the pins, cross-arms or poles, if of wood, are set on fire. In the

mountain districts with modern insulators our line troubles are practically nil. Those without experience in the fog districts cannot realize the difficulties of insulating against a heavy fog. The weak point of the transmission system is the insulator. With an insulator to stand 100,000 this voltage is possible.

To sum up, experience shows that it is easiest to operate a line at 50,000 or 60,000 than at 25,000 or 30,000, assuming that a considerable amount of power is transmitted.

AMERICAN PRACTICE IN HIGH TENSION LINE CONSTRUCTION AND OPERATION.*

BY F. A. C. PERRINE, D. Sc.

A CHARACTERISTIC of American practice is that it tends toward standards, not only in the matter of the sizes of units, speeds and manufacturing appearance, but also in the methods of producing results and in the types of engineering. While it may be true that this tendency was originally based upon a desire for cheap manufacture and interchangeability of parts, at the same time it must be understood that the present elaboration of this policy is somewhat due to the fact that in so large a country the ideas of the best men cannot be directly applied except as they may be adopted for standards. No one section of the country produces the best men necessarily, nor does any one group of engineers dominate our practice. On the contrary, the meetings of our engineering societies have taken the character of sittings of committees, where are presented many plans, and where all plans are carefully discussed and sifted. From those presented the best is chosen and becomes the standard.

Accepting these results as the standard does not imply that there is general in this country a spirit of copying or of servile imitation among the engineers. On the contrary, we feel that the result of the attitude so prevalent in American engineering at the present time, of establishing standards, has introduced a wise spirit of conservatism, and has thrown the burden of proof upon each one presenting a new idea. At the same time it has resulted in raising the character of the average engineering work throughout the country, until today good American engineering can be found, not only in the great spectacular plants near enough to the large centers of progress to have the personal attention of the most experienced engineers, but in consequence of this system of practice an equally good type of engineering can be found in the plants in the out-of-the-way deserts or mountain regions, where the local engineer of good capacity, knowing his conditions thoroughly, has relied upon the standards established by his fellows in those particulars where his own experience has been limited, and in consequence a plant is produced, not only more perfectly adapted to the particular circumstances of its surroundings, but in all details more thoroughly satisfactory than could have been designed under any other system. Our rule is that invariably one should adhere to well-established practice and introduce such modifications as are made necessary by the local conditions. This does not limit the full employment of the energies and brains of the local engineer, since, without a special consideration of outside details, there are always in every transmission plant particular circumstances which tax the ingenuity of the best. That this is the general method of American practice will be seen by any one who consults the report of the standardizing committee of the American Institute of Electrical Engineers. The report covers, not only units, standard methods of testing and details of manufacture, but also procedure, both outdoor and in, for all types of plants, and this report in itself has resulted in a certain similarity of type where problems to be solved are similar.

The work of the transmission engineer lies in fields so essentially dissimilar that, even in spite of this general tendency, it may be difficult at first view to ascertain what is the American practice in work of this class. On closer examination one finds, however, this work falling into natural groups dependent on the length of transmission and the voltage employed, though what has been done has been materially modified by the date of erection, since during the past ten years modifications in the arts have been necessarily reflected in the types of construction.

The general groups have been somewhat decided by the manufacturers of machinery, who have presented as preferable certain available voltages. Above 2400 volts, where transmission proper really begins, the first voltage now commonly employed is 6600, which figure has been established as standard by the needs of the lighting plants in the great cities, and has been adopted by the transmission companies in place of either a higher or lower voltage, mainly because it is a standard. For this voltage direct generation at high pressure is almost invariably used. The next higher voltage now commonly employed, and now practically the first one for which step-up transformers are used, is 15,000. During the past few years this has taken the place of transmissions at 10,000, 12,000 and 13,000, and it is today the established voltage for high-tension electric railways, the general reason for its establishment as a standard being that this voltage is not more difficult to handle, as regards insulation or switching, than the three last-mentioned lower voltages, and, furthermore, that where the lower voltages have been previously established, the sphere of operation of the transmission plant has been found to be rather too much limited. There are in the Rocky Mountain region and west a great number of the older plants opeating at 10,000 volts, and whenever direct high-voltage generation has been attempted, voltages of from 12,000 to 13,000 volts are used; but, at the same time, the majority of the plants which have used the lower pressures in the past today have circuits with special transformers operating at the higher figure. The next step is to 25,000 volts, which is the highest figure reached without special study of insulators, switches and lightning arresters. This voltage has been successfully handled without serious trouble during the past six years. A voltage of 35,000 is employed in a number of plants built about five years ago, and at this figure the special difficulties due to line capacity, insulator size, erratic lightning-arrester effects and switching begin to make themselves seriousiy felt. Above 33,000 volts the standard voltage is called 60,000, although in all plants that have heretofore been established to operate at this pressure there have been installed transformers arranged for connection to various voltages of from 40,000 to 60,000 volts, and the majority of these plants are today operating at about 50,000 volts, some of them being unable to operate at the highest pressure on account of the character of line insulators originally installed. In the choice of voltage for any transmission it is considered the best practice to establish it at the rate of 1000 volts per mile, provided the length of transmission be not above sixty miles, since above 60,000 volts no commercial work has been regularly attempted. In the table recently presented by the transmission committee of the American Institute of Electrical Engineers, the highest average voltage per mile for any one class in their report is 840; but in examining this table it must be remembered that their correspondents have reported the total length of line in service, so that, if a plant operated two lines fifteen miles each in length at 1500 volts, their table would indicate an operation of 500 volts per mile, although for each line the transmission was at 1000 volts per mile.

In the generation of power the revolving armature machine has almost disappeared from the new plants, and revolving field generators have become so settled in type that those produced by different manufacturers are hardly distinguishable by the casual observer. For the low-head plants using turbine wheels it is necessary to provide for a 50 per cent. increase of speed, and in the high-head plants, where impulse wheels are employed, a strength

* A paper presented before section D (electric power transmission), at the International Electric Congress, St. Louis, September 13, 1904.

sufficient to withstand a speed increase of 100 per cent. must be allowed to provide against damage from overspeeding should the power be thrown off and the water continue to flow. The machine fulfilling these conditions and practically adopted by all the manufacturers is characteristically a revolving field machine, with the poles keyed to a cast-steel spider, the field windings being of copper strip wound upon edge, the armature being constructed of a cast-iron box girder supporting the stationary armature laminations. Almost the only departure from this type of construction for power transmission work is found in the balanced type of inductor machine, where the field is magnetized by a central stationary field coil wound with copper strip, the armature in two halves, symmetrically arranged around the central core, being of laminations supported either by cast-iron rings connected together by cold-rolled steel bars or supported by a steel shell to which the armature laminations are keyed.

Various station voltages have been employed, but, where direct generation at 6600 to 12,000 volts has not been resorted to, the practice is setting more and more to the use of about 2300 volts, this being chosen because the lower voltages require large extra station copper and the higher voltages are felt to introduce unnecessary station difficulties of insulation and switching. For switching, the present type of 2300-volt oil switch has been so well developed, by reason of the great number of plants operating at this pressure, that for handling a particular amount of energy it is both cheaper and better than any 500-volt switch on the market.

For plants operating at less than 25,000 volts the step-up transformers in use are about equally divided between the water-cooled, oil-filled types and air-blast types. Where a good supply of water is to be readily obtained, the oil-filled transformers have generally been given preference, as they can be more readily adjusted for a varying flow of water at different loads. The question of the relative fire risk from the two types has been extensively discussed, and it can hardly be said that any very definite conclusion has been finally reached, though the weight of opinion seems by far to be that the fire risk is at least not increased by the use of the oil-filled transformers, and the actual risk in either type seems to be a matter largely of installation. It is perfectly true that there have been some very serious fires, resulting in the complete destruction of power plants, where oil-filled transformers have been used, but in each case the fire has started outside of the transformers, though they themselves, by reason of being installed without reference to safety in case of fire, have furnished fuel which has augmented the conflagration. Today the conditions of installation for safety are better understood, and it now only remains to be decided whether, in the case of a fire actually arising, the oil shall be run out and the transformer cases filled with water, or the whole transformer protected either by running in an excessive amount of water through their cooling coils, or by so installing them that the transformers may temporarily be submerged to within a few inches of their tops. Actual protection of transformers by running water through their cooling coils has been found to be effective in at least one serious fire.

For high-tension switching use has been made of a long arc-breaker between carbon terminals and long-inclosed fuse—a fuse drawn through a tube filled with a fine, non-conducting powder—and of oil switches. The first two types, while interrupting the circuit well, draw an arc of excessive length and produce a surging which may result in an increased potential of at least as much as 50 per cent. In consequence, these types are rapidly disappearing, except in plants operating at 15,000 volts and below, where the carbon break is preferred to the inclosed fuse, though it is common to install the two in series, allowing the fuse to operate as a safety device, but not for the purpose of switching. The type of fuse where wire is drawn through a tube filled with powder was found to operate successfully up to 40,000 volts and without serious surging on the circuit, but the powder being blown out with great force and scattered over the entire station is in consequence not allowable. The oil switches mainly employed are those with the vertical break and those with the horizontal break. The vertical break switch has the advantage that the amount of oil contained in the oil tank is relatively small, and will add to possible conflagration only a slight amount of fuel. This switch is often found on severe short circuits to blow all the oil out of the tank unless the tank is built very strongly, when it becomes necessary to insulate the plunger from the tank as it enters the switch. The horizontal break switch, while containing a large amount of oil, will for the same length of break handle about 25 per cent. more energy at any definite potential. This switch can successfully be used at 60,000 volts, and up to the present time has not been found to blow the oil from the tank. These two types of oil switch are the standard to-day, no distinct preference being given to the horizontal switch, though the writer believes that in the future this type will be used as a standard for the highest potentials.

Transmission with two-phase connection of circuits, whether using three or four wires, has for voltages above 6600 given place entirely to transmission with a three-phase connection, though three-phase transmission with two-phase distribution described by Mr. Scott at the International Congress of 1893 is very extensively employed.

The relative merits of the delta and star connection of the lines to the transformers is still somewhat in dispute, so much so that in plants of the highest voltages, where several voltages are provided, certain of the lower voltages are obtained by delta connections to the transformers, while the higher voltages are to be obtained by a star connection. In general it may be stated that up to 25,000 volts the delta connection is generally preferred, principally because with this connection a ground upon one line does not necessarily result in a short circuit, and, furthermore, the service is not necessarily interrupted in the case of the failure of a single transformer. At voltages higher than 25,000 volts the transformers for delta connection become more difficult to build and insulate. Furthermore, a single ground anywhere produces disturbances of a serious character, and in consequence the star connection with the grounded neutral is employed, advantage being taken of the fact that a grounded neutral aids in the distribution of unbalanced loads, and furthermore, the rise of pressure which may occur from line discharge at the time of an open circuit or a short circuit is not so likely to produce serious results.

For the distribution of current through the low-tension mains it is generally the custom to transform to 2300 volts, two-phase unless either the load is mainly one of motors, or unless there are important motors of considerable size to be supplied at a distance of half a mile or more from the substation. In such cases three-phase star-connected four-wire distribution is employed, allowing the connection of distributing devices either to a 2300-volt circuit between lines and the neutral wire, or a connection to a 4000-volt delta circuit for balanced loads. This combination of circuits is found to be extremely useful where a mixed load is to be supplied at varying distances.

The high-tension lines themselves are preferably run over private right of way. Railroad rights of way were at first highly prized on account of the entire absence of trees and disturbing structures, and furthermore, on account of the fact that inspection and repairs are most easily provided for; but experience with such lines has proven that, for transmission at even so low a tension as 15,000 volts, the interference with insulation by the smoke from the locomotives, which covers the insulators, more than counterbalances all the advantages, and today such rights of way are more commonly shunned than sought. Where railroad locomotive smoke combined with sea fog is encountered, it becomes absolutely necessary to clean each insulator at frequent periods, even though the voltage of transmission be not more than 5000 or 10,000. Along the country road this difficulty is not apparent, but in some localities farm structures and trees interfere with the transmission, so that in general it may be said that a private right of way that the transmission company can absolutely control is much to be preferred.

In the most recent types of construction the height of pole is limited as much as possible. Where there may be some increased security from malicious disturbance in the use of high poles and decrease of line capacity may be expected, these advantages are only obtained at the expense of stability and at an increased cost. A pole thirty-five feet high set five feet in the ground permits the safe installation of either a single three-phase line with a spread of as much as six feet by supporting one insulator on the top of the pole and the other two on the ends of a long cross-arm, or it may be used to support two three-phase circuits on opposite sides of the pole with a spread between wires of three feet by the use of two cross-arms, and at the same time such a pole permits the safe installation of telephone or other signaling circuits on brackets or cross-arms at a safe distance below the power lines. These poles should not be less than eight inches in diameter at the top and not less than twelve inches in diameter at the ground line. Variations from these dimensions may be considered as being due to special considerations based upon the location of the lines or arrangement of the circuits. It is true that such a standard pole may only be arrived at after a consideration of the wind stresses on the particular lines taken in conjunction with the spacing of the poles, but as the maximum pole spacing on transmission lines is about 135 feet, and at average wind velocities the pole dimensions may be considered safe. Extra strength required by variations of wind stress, either due to an increase in the number of wires or to a necessity of allowance for sleet, is more commonly taken care of by shortening the spans than by an increase in the size of the pole. In some cases where severe sleet conditions are to be encountered and the wires changed, it is the practice to install these poles at not more than fifty feet apart.

The material used for poles depends largely on the locality. In the southeastern states chestnut is the favorite wood; along the Canadian border and along the Rocky Mountain regions cedar is employed, while square-sawn redwood is used almost exclusively on the Pacific Coast. With increase in voltages and consequent increased trouble from insulators, a demand has arisen for a pole-line construction that will permit a decrease in the number of insulators and allow an increase in the size of each. This has been accomplished by the use of galvanized iron towers not less than forty feet from the ground line to the wires and spaced about 500 feet apart. One plant in Mexico has recently successfully installed this method of construction. A second in the same country has contracted for its material and a number of plants in the United States are contemplating its use. The question of the life of wooden poles depends not only upon the character of the wood and its condition when cut, but also upon the local conditions of atmosphere and soil. In some places the poles which are available have no longer life than about five years, and, in the extreme, wooden poles cannot be greatly depended upon for a longer period than fifteen years, though the redwood poles installed along the lines of the transcontinental railroads west of the Rocky Mountains have in many instances given a life up to thirty-five years and are still found to be in good condition; but these poles are set into a soil strongly impregnated with alkali in a country where rains are few and the air generally dry. Nothing is known as yet of the life of the galvanized iron towers except from the windmill practice, where towers which have been galvanized after all punching and machining is done are found to be in good condition after a period of ten to fifteen years.

The cross-arms in use are almost invariably made of pine without treatment other than painting. These arms are let into the pole from one to two inches, being held by bolts through the pole and arm, and when long are additionally supported by braces. Even with higher poles wood arms are used, the general feeling being that there is less probability of the circuit being completely disabled should an insulator break and the line fall, if it falls upon a wooden rather than a steel arm. At the same time an experiment in the use of wooden braces has not been found to result in any advantage. In consequence, flat, galvanized-iron braces, established a number of years ago as standard by the telegraph and telephone companies, are now almost universally employed in the construction of transmission lines. With increase in spans and voltages the insulators are increasing in size. This condition will probably in the future demand a strength of arm greater than can be obtained by the use of wood. This problem, however, has not as yet obtained a definite solution.

For plants operating below 25,000 volts much use has been made of glass as a material for insulators. Glass has been for many years the standard insulator material in American telegraph and telephone practice, and in spite of many experiments that have been tried with porcelain, it is still considered the best and cheapest material for this service. However, in transmission work one of the great advantages claimed for glass in telephone and telegraph practice disappears. The engineers of these companies claim that it is important to provide against dark, narrow spaces within the insulators, on account of the fact that they form the homes of insects. The transparency of the glass largely obviates this difficulty. Where large insulators are used, such as are employed by transmission companies, the spaces within the insulators are well lighted from below, and the transparency of the material is not important. Glass is comparatively fragile, and for transmission work it has nothing to recommend it except low first cost and cheap inspection; these, to be sure, are very often overpowering advantages when the voltage is low enough, so that the particular form of insulator used gives a large factor of safety, and in consequence up to 15,000 volts glass insulators are generally preferred unless there are special climatic conditions which render them liable to fracture. Many series of tests have shown conclusively that the porcelain insulator has a greater mechanical strength, is less liable to surface leakage, has a safe dielectric strength, and in addition that it is exceedingly difficult to so break the head of a porcelain insulator as to allow the wire to fall away from it. The one disadvantage of porcelain is that there is an uncertainty as to its solidity, and that it is only possible to ascertain its solidity by most careful high-voltage tests. The question of the form of high-voltage insulator is as yet in high dispute, operating engineers being inclined to a design where the petticoats are very long and comparatively close together, so that great creeping distance be given over the surface of the insulator, between line and line and between line and pin, comparatively little regard being placed on the flashing distance. Engineers of the manufacturing companies, however, incline toward one of a much more open type of large diameter and with few petticoats. This latter form undoubtedly gives the greatest sparking distance, has the least dark spaces within it and is more readily cleaned by rain storms. It is also important that such an insulator be operated at high voltage without noise, and, as there is a definite loss of energy whenever the insulators on a line are noisy, it may be safely predicted that the open type of insulator is to be the one that will be in the future considered as the standard.

While insulator size may be largely determined by form, at the same time we may in general note that up to 10,000 volts, insulators, whether of glass or porcelain, have a minimum diameter of about five inches. A seven-inch insulator can successfully be used on voltages as high as 25,000, a thirteen-inch insulator is sufficient up to 40,000 volts, while at 60,000 volts it does not seem safe to install insulators having less diameter at the top than fourteen inches. A greater size would unquestionably invariably be used for these high voltages if the problems of the manufacture of porcelain and support of the insulator were altogether solved.

For support of insulators on cross arms it is necessary to provide that the lowest petticoat be raised above the cross-arm as much as the radius of the insulator, and, as the strain comes on the extreme top of the pin, it is obviously difficult to successfully support the largest size of insulators by means of the common pin in cross-arm construction. By using carefully selected woods this has been successfully accomplished for insulators up to

eleven inches in diameter, but at 40,000 volts in bad weather such insulators carry enough current over the city to char a wooden pin. Accordingly practice has settled to the use of iron pins in plants operating above 25,000 volts. At this voltage and below the wooden pin can be successfully used and indeed forms a certain protection to the line by reason of the fact that the pin itself is a safe insulator, and is only in danger of being burned where the insulator is punctured. Above this voltage, however, only metal pins can be employed, not only on account of the large size of the insulator, but also on account of the fact that there is much burning of wooden pins. The manner in which these pins are burned has attracted considerable attention, having presented some problems which are exceedingly interesting. There is no doubt but that the effect is due to leakage over the surface of the insulator, but it is extremely interesting to note that in some cases the pin is actually charred, whereas in other cases there is an apparrent disassociation of something in the wood, and peculiar salts are left behind, either reduced from the atmosphere or from the material of the wood itself. This matter was discussed by C. C. Chesney in a paper read before the American Institute of Electrical Engineers.

The materials that may be used for pins are locust and eucalyptus. The latter wood is decidedly preferred in the plants west of the Rocky Mountain region and where it is readily available, as the wood has been found to be as strong as hickory, dense and readily handled when thoroughly seasoned and dried. For the largest sized pins, however, as has already been said, no wood is entirely satisfactory, and in consequence use is made of malleable cast iron or cast steel.

As regards conducting material, it may, of course, be said that the only materials at present available are copper and aluminum. For a number of years there has been a discussion of the possible use of iron for short lines on high-potential plants, since the smallest copper wire that may successfully be strung is unnecessarily large under such circumstances. This procedure, however, has not obtained the approval of any of our electrical engineers. The copper wire is invariably uninsulated in high-tension work, since it is correctly believed that no insulation is a true protection, and the frank nakedness of the bare wire is a warning, and in consequence a safeguard to those who are compelled to work near the line.

Copper is used either soft, hard-drawn or stranded. For transmission work, where the wires are smaller than three-tenths inch in diameter, use is not made of soft-drawn wire, and it may be stated that the standard in American practice is to use the soft-drawn wire only for large, low-potential circuits where the small change in conductivity due to the hard drawing is an important factor. Up to three-tenths-inch hard-drawn copper may be considered standard. Between three-tenths and four-tenths-inch diameter the practice is evenly divided between solid hard-drawn wire and strand. Larger than four-tenths-inch strand is almost invariably employed. Some use has been made of solid aluminum, but, as the material must be handled with great care, it has been found generally to be the better practice to employ aluminum strand, which is more readily installed and more reliable after installed.

Preference between aluminum and copper is almost entirely a matter of price for transmisison lines. It is true that aluminum is stronger in reference to its weight for different conductivities than copper, but at the same time it is materially larger, and the resultant transverse wind stress on the line is greater. For short lines, delivering a small amount of power at voltages of 40,000 or above, aluminum is decidedly to be preferred, since it is found that at these voltages a wire less than one-quarter inch in diameter will discharge through the air, and this discharge may result in a considerable loss of energy. Accordingly, it is not possible at these voltages to successfully use wires less than three-tenths inch in diameter, no matter what the amount of energy or the distance. Accordingly, where the amount of energy and the distance may result in the loss not being the determining factor, aluminum is much preferable for the reason that at a definite size it is materially cheaper than copper. Where salt sea fog is to be encountered, both aluminum and copper are acted upon. The action on aluminum is greater than the action on copper, and in consequence copper must necessarily be used. Where such conditions are not encountered aluminum is an entirely safe material, provided it is not exposed to the elements in contact with any other metal. The joints, therefore, must either be made of aluminum of the same quality as the wire, or the joints must be carefully insulated so that no moisture will penetrate. Aluminum must be strung with careful reference to the temperature at the time of erection, since its coefficient of expansion is very large, about three times the coefficient for copper, and experience in the erection of copper lines will result in an unsafe aluminum line. Careful tables have been prepared as to temperature, span and sag, and when these tables are followed no apprehension need be felt as to the safety of the line.

The most difficult problem at present encountered in the construction of high-tension transmission lines is that presented by the lightning arresters. For voltages up to 25,000, the non-arcing types of lightning arresters, either with or without series resistances, may be successfully used. Above this voltage and where large amounts of energy are available, these arresters are found to be short-lived, and up to the present time no thoroughly satisfactory arrester has been presented, which does not, when interrupting the ground circuit after a discharge, injure the insulation of the line and transformers. The horn form of lightning arrester developed in Germany has been found to operate with invariable success so far as the lightning arrester itself is concerned, but, as it is interrupting the ground circuit, it draws a large arc, and oscillations are produced on the line, which in many cases have been found to have more serious result than the discharge they were installed to remove. Condensers in parallel with the lightning arresters and ingenious arrangements of arresters and resistances have been used with some success, but none of these plans may be considered to be entirely satisfactory for the highest potentials operated from the largest generating plants.

In the operation of such lines every effort is made toward maintaining continuity of service. Such lines are carefully patrolled, even when it becomes necessary to build a special runway for the patrolman, and it is remarkable with what certainty these experienced men can predict the hours of life of a failing insulator and provide for voluntary interruption of the service in time to remove the imperfection. Duplicate lines for long-distance work is in an invariable necessity, though by far the best protection that can be offered for service is the supply of current from different power stations over lines following different routes. The present tendency is toward the consolidation of plants, not only for the purpose of decreasing the general operating expense, but more particularly providing continuity in the case of the most serious accidents. No difficulty is experienced in operating in parallel plants widely separated, and where a number of plants are feeding into the same network, two certain plants are assigned the regulation of the entire system, others feeding the circuit being allowed to operate their machinery at full load continuously. The line capacity offers the most serious problem in determining regulation where the loads vary widely, but this quality becomes important only for great variations of load, which, as the plants are increasing in size and load, are disappearing. When proper care has been given to the installations of the lines and where duplicate lines and plants are provided for, care in operation and patrol of the lines has resulted in success both from the engineering and financial standpoint.

We are glad to note a most decided change for the better in THE JOURNAL OF ELECTRICITY, POWER AND GAS, San Francisco, Cal. The August number, besides having a complete unofficial report of the Pacific Coast Electric Transmission Association discussions and papers, given at the Monterey convention, gives a mass of information on electrical matters, with drawings and pictures, that is most acceptable.—*Trade Price List, Boston, Mass., October, 1904.*

SOME DIFFICULTIES IN HIGH TENSION TRANSMISSION AND METHODS MITIGATING THEM.*

BY J. F. KELLY AND A. C. BUNKER.

IN discussing the conditions which affect and limit the constants and operation of high tension lines, pressures of over 30,000 volts and lines of over fifty miles in length only will be considered.

The usual relations between voltage and length of line, namely. "1000 volts per mile," or "the pressure in thousands of volts equals one-third the number of miles," cannot be applied generally until all sources of interruption are taken into account, so that the length of transmission does not altogether determine the voltage to be used, for a voltage as high as possible will be used and its value determined from local and climatic conditions.

These will be the principal factors in the design of any line, as all the other constants, except, perhaps, the kind of conductor, are interdependent upon them. Since there is always some doubt as to the successful maximum operating voltage which these conditions will permit, and just how the line will be affected, it is well so to design the step-up and step-down apparatus that, without seriously affecting its capacity, several voltages, say 30,000, 40,000, 50,000 and 60,000 volts, or even higher, can be obtained at will. This arrangement will permit the power to be transmitted with the highest possible voltage, and the causes which prevent the use of the next higher pressure can be studied and overcome if possible. As a new plant is usually started with a load less than its capacity, there will be no serious decrease in the efficiency by this method of experimenting.

The principal causes of interruption of the supply of power in the past and at the present time are: Open circuit, grounds, short circuits and other circuit changes which produce oscillations.

These are directly and indirectly traceable to weak insulators, lightning, defective pins, burning of poles at the ground, storms and to a class which might be called unexpected sources. All the above may not be common to one locality, but all may exist on a single system. It may be said that where the quality and design of the apparatus and accessories for the generating and substations have been selected with regard to their requirements, and where such are afterward intelligently handled, almost the entire list of troubles which are at the present time affecting the continuity of power service may be credited to the line.

In designing a transmission line, experience has shown that the most careful study of local and climatic conditions should be made in order that all the facts and data bearing on these and their probable effects may be obtained.

It has been demonstrated that one transmission line for voltages over 30,000 will not give continuous service except when ideal climatic conditions exist. There is one, and possibly two, plants that have given continuous service for more than a year, with two circuits each, and with climatic conditions better than generally exist. It is believed that, in some localities, even with duplicate lines, the best insulators obtainable at present, and with perfect circuit breakers, the maximum voltage which would permit continuous operation or delivery of power would be 40,000 volts, or possibly 50,000 volts, with the utmost care and diligence.

The selection of the line insulators depends entirely upon the voltage, mechanical strength required, and the localities through which the line passes, more particularly the latter, as lines have been operated at 45,000 volts with two or three types and sizes of insulators in as many different sections. The design of the insulators should be such as to give the smallest amount of still air space and the greatest accessibility for wiping by hand. Fog occurring at the same time or intermittent with soil, factory or car dust is one of the surest causes of trouble, and reduces probably, to the greatest extent, the effective commercial size and value of insulators. Upon examining a large number of insulators which had to be removed, it was found that the dust, with which they were coated, was thickest in the still air spaces, and was as thick on the vertical as on the horizontal surfaces. It has been found that where insulators were subjected to fogs or dust alone (except sea fog), the same number of troubles did not occur as when both appeared together. Where insulators are covered with dust, parts of each year, it has been necessary to shut down the circuit from one to three times during the dust season to wipe them clean. This can be done while in position and without disturbing them unless they are found to be damaged.

The fact that insulators are successfully tested for high voltage before they are put up does not necessarily prove that they will not cause any trouble when on the line. Insulators which were tested for 120,000 volts water test for one minute have given trouble in less than a month after being placed on a 40,000-volt line. Other types which had stood 40,000 volts water test for five minutes have been known to be unsatisfactory for 13,000-volt city (overhead) service, though this would not hold in every city. The greatest value of electrical test for insulators before being used is to determine whether the various parts are homogeneous and whether they have been properly cemented together.

If an insulator was made up of three separate pieces, each having been tested for say 80,000 volts before cementing, it does not follow that the completed insulator will stand 240,000 volts, or even 120,000 volts. The striking distance of the completed insulator, together with the quality and manner of cementing, determines very largely the final test voltage, even though they have sufficient creeping surface for a higher voltage.

In cementing a large number of insulators together, it was noted that the percentage broken down under test could be reduced almost one-half by a little more care in the method of cementing. When insulators are glazed together at the factory, a uniform insulator should be obtained. The conditions for transmission are very good, if, for continuous use, 1 per cent. of the insulators does not have to be replaced each year. Taking a circuit having 12,000 insulators installed, there would be at least 120 renewals each year. Each poor insulator is liable to cause a disturbance or interruption, and the system might be subjected to an average of ten per month.

If some seasons of the year are more severe on insulators than others, there may be more than thirty cases of trouble per month. It has been observed that, where insulators were giving trouble on a line operating at 40,000 volts, reducing the pressure to 30,000 volts did not produce a like or immediate decrease in the number of insulators broken per month. The total number remaining seemed to be in a more or less weakened condition, and would continue to break down after the line pressure was reduced, though after a certain period of time the breakage per month was less.

The difficulties of taking care of lightning discharges increase much more rapidly than the line pressure, for the reason that any disturbance or change in circuit conditions, produced by getting rid of, or dissipating, a change in a circuit having high voltage and high inductive and capacity reactances, may set up oscillations which, if not serious to apparatus, are disastrous to regulation and service. Various combinations and multiples of low voltage types of arresters have been used, but where these have not had the proper addition of a resistance they have seldom failed to be completely destroyed when the particular stroke or circuit change occurred. It has been clearly shown that the same arrester could not, without special adjustments, be used on all parts of the circuit, and that arresters performing their function for a lightning stroke, or taking the kick-back from a short circuit opening, when a given number of generators, length of line, or transformers were in circuit, would not so operate for another number of generators, transformers or length of line. This may have been due to the increased inductance in circuit obtained from a smaller number of generators or transformers, to a longer length of line, to the nature and duration of the arc in opening the short circuit, or to any number together of these conditions. Where a resistance is used with any type of arrester, in order to keep the value of current which would flow over the arresters, to a given percentage of the load current, the amount should be such that five or six times the normal impressed voltage can be taken care of.

*A paper presented to Section D, Electrical Power Transmission, of the International Electrical Congress, at St. Louis, September 12, 1904.

A modified form of the Siemen's arrester has been used on circuits up to 50,000 volts with a fair degree of success when they were correctly adjusted for the different positions of the circuit, and, where a resistance was placed in series, the voltmeter cards were not painted badly when lightning or a short circuit occurred. This design can be greatly improved, and no doubt would give very good results and thoroughly protect connected transformers.

The low cost, ease of construction and their outdoor serviceability are points in their favor.

Perhaps the most reliable arrester is one consisting of an inductance and condensance in parallel, so that any frequency variation from the normal would cause a certain value of current to flow. This type, immersed in oil, would be rugged and could easily be adjusted for any position of the circuit.

One of the best means of dissipating an induced charge or stored energy in a line is by having a distributed load along the circuit. If this load has a grounded neutral, the effect of a lightning strike will be greatly reduced and more easily taken care of by the regular arresters. The star connnected line with grounded neutral has, however, some disadvantages of equal importance, which should be carefully considered before being adopted.

In practice, next to troubles from lightning, short circuits on long lines of low ohmic and high inductive and condensive reactances produce the most serious consequences. It is, therefore, necessary to use accessory apparatus which will discharge the circuit between wires, as well as between circuit and ground. This point should not be lost sight of in the selection of arresters, and in their connection to the circuit. When a line is short circuited from any cause, there is a rush of current, the value of which depends upon the impressed voltage and the impedance of the circuit up to the point of the short circuit. When this current is suddenly interrupted, the voltage induced depends upon the constants of the circuit and increases in value with the length of circuit, distance between wires, the amount of inductance of the connected apparatus, the inductance of the rupturing arc and its duration, the impressed voltage and the instantaneous value of the current when the short circuit is opened. This induced voltage will be small or of little importance if the short circuit is opened at or near the zero value of the current. In operation, induced voltages have been observed when opening a 40,000-volt 100-mile line when short circuited, or from two and one-half to six times the normal voltage, as measured by the length of air-gap broken down by the kick-back. In the more severe cases, some point of the system usually suffers; that is, there will be a discharge or arc across some point of the line or transformer terminals, a puncturing of transformer coils, break-down of insulators, the destruction of lightning arresters, or some other like effect. In nearly every case the circuit is put out of service unless efficient arresters are used. The fact that there is not more damage done than would seem likely from the voltages observed is, no doubt, due to the property of solid dielectrics of withstanding momentarily very high voltages and which would be punctured in an interval of time. Air having the property of breaking down immediately upon the application of the proper voltage for the gap is the probable reason why these manifestations more commonly occur in air, from terminals, and around other dielectrics.

The troubles from the charring of wooden pins were due to the continual leakage of current over dust-coated insulators. In some localities pins would last only from one to three months. This was entirely corrected by placing a metal short circuit around the pin. Molding at the thread, which is often noticed where the line passes through a marsh, can be prevented only by the use of a metal pin. Several lines have now been equipped with steel pins and no new troubles have developed; but, on the contrary, a decided decrease. It would seem that for large high-pressure lines steel pins should be used exclusively. Their initial cost is from one and a half times to twice the price of wooden pins, though cheaper in the end. Soft lead gives better results for the thread than any composition. The molds should be made so that enough lead can be used to extend a little way below the bottom of the thread, as this will give a good bearing to the insulator over and above that obtained from the thread. This will greatly add to the mechanical strength of the insulator and of the line, as, with the ordinary pin, the insulator is the weakest element of the line. Precaution should be taken to have the thread portion short enough so as not to come in contact with the top of the insulator. This will prevent the tops being forced off when the insulators are put on the pins, and will allow a firm seat at the other end of the thread.

The service given by wooden pole line construction is subjected to interruptions from falling and burning poles, due to decay, freshets, forest or grass fires, the large number of insulated points, and from the necessary short length of the poles. The decay of poles can be greatly lessened by continual inspection and care after they are up. The idea that poles of the right kind of wood for the soil can be placed in the ground and last for ten or twenty years has been the cause of many and costly repairs. One six-year-old redwood line, with butts treated before raising, had to have 33 per cent. stubbs. Another redwood line, untreated, had to have 10 per cent. stubbs in three years. Another line of untreated cedar poles required 35 per cent. stubbs in six years. In long lines and even in some short ones soils may be found that have an entirely different effect upon the life of the same wood.

Engineers are many times prevented from buying poles at the proper time to have them cut, on account of the interest charge on the cost of the poles and erection, from the time the poles are paid for to the time when the wires are strung. The freight and hauling charges on from one-fourth to one-third more weight will offset a large amount of the interest charge. The result is that the poles are put in green and, unless they are afterward treated, decay will begin in a short time. If it is possible to obtain seasoned poles, their life will be much increased by thoroughly treating the butts before raising than by any subsequent single treatment. When green poles are used, no treatment should be given before raising, but the butts should be treated after the first dry season, and retreated every second or third season after, this depending upon the material used and condition in which the pole is found. There are on the market several kinds of treating material which are showing good results. This after treatment consists in digging the earth away from the pole for about eighteen inches below ground line, and treating this surface, together with that eighteen inches above ground line, after the decay and earth have been cleaned off. The old ground line should then be changed by banking earth up around the pole. The cost of this treatment varies from 60 cents to $1 per pole, depending upon the location of the poles and the kind of material used.

At the same time the butts are treated, the pole tops, gain cracks and ends of the arms under the dead circuit should be painted. This is the best known method whereby wooden construction, as a general thing, can be made to last the so-stated twenty or twenty-five years.

The burning of the poles at the ground has been the cause of interruptions even where the line was patroled twice a day, but the remedy is simply a question of persistence and expense in keeping the right of way cleared of all growth. It might be noted here that, even with a generous right of way kept cleared, the wind may carry the heat from a fire toward the line. Two cases are on record where the heat from a forest fire along a pole line was not great enough to harm in any way the wood arms or poles, but did cause large numbers of glass insulators to crack and fall to the ground. Porcelain is less affected by heat than glass and probably would not have caused as much breakage.

Some of the unexpected sources of trouble show how detailed must be the design and care of a line, and what insignificant and harmless-looking object and occurrences may cause the complete shut-down of a circuit. After everything imaginable has been considered and provided for, there may still be accidents. One case is known where some dried hay was carried up into a 40,000-volt line, with the result that it was set on fire and produced an arc that shut off the power. The burning hay, being carried on by the wind, did considerable damage. On another line, a flock of pelicans flew into the telephone circuit which was strung

several feet below the power wires. The span was something over 600 feet, with a sag of nineteen feet. The telephone wires were struck so hard as to wrap them around the power circuit.

Another case was where a long piece of bark was blown several rods across a forty-two-inch line, with the usual result. On the same line, during one season, there were three interruptions in one locality, caused by large birds getting across two of the wires.

The falling out of step of synchronous apparatus, while not frequent, does happen, and, unless the breakers operate promptly, other apparatus may add to the trouble and the circuit be opened. On the other hand, with proper attention to field strengths, synchronous motors have several times been known to keep in step during temporary short circuits on their connected direct current generators, the direct current breakers being purposely set at a high current or tied in.

The question as to whether wooden poles or steel towers should be used for a given transmission will be determined by the advantages of one over the other for the conditions to be met.

In countries where wooden poles are plentiful and inexpensive, it is probable that every expedient will be resorted to before steel towers are used.

One of the principal advantages of wooden construction is, that, in case an insulator is broken, allowing the wire to come against the arm or pole, the burning, which takes place almost immediately in most cases, may continue for several minutes before a blaze is started which will short the circuit. Several times it has been observed that from twenty to thirty minutes elapsed from the time trouble was first noted by the ammeters or telephone until it was necessary to shut off the circuit. In one case a 40,000-volt (grounded neutral) wire lay on a dry cross-arm for several hours before the circuit could be shut off, and at the end of the time the arm was not badly charred. With a duplicate line, ample time would in most cases be given for changing from one circuit to the other, or to cut out the affected circuit, providing the telephone line was operative or the men at both ends recognized the difficulty.

For the past four years, engineers have tried to adopt, where possible, steel towers, instead of wooden poles, as a means of correcting a large number of line troubles.

At first thought, towers would seem to solve all difficulties previously experienced, and certainly do eliminate a great many. The spans can be increased, so that as low as eight towers per mile can be used with safety. This would greatly reduce the number of insulators, which can be larger, and the means for their attachment to the towers can be quite elaborate without exceeding the cost of the other construction. The height of towers can be greater, which will decrease troubles from wires, branches and other material being thrown or blown across the circuit and reduce the breakage of insulators from the heat of forest or grass fires. If galvanized or painted occasionally, their life would be greater than could be expected of wooden construction.

Towers can be erected in places even more difficult of access, since they can be taken apart in pieces of lighter weight than a wooden pole. They would offer a more or less good lightning path to ground which would help to prevent the injury to connected apparatus; but will no doubt subject each insulator to greater strains. Any leakage around, or puncturing, an insulator will mean the immediate shut-down of the circuit, and, in order to prevent the immediate shut-down of the entire system, overload and reverse circuit breakers of the best possible design will have to be used.

Auxiliary insulation of sufficient mechanical strength could be used to reinforce the insulators carrying the conductors, as the towers would be able to carry considerable more weight than wooden poles for the same cost per mile.

The most economical design of a tower is not suitable for a good many places where the line would have to be erected, and could only be universally used on a private right of way. On railroad rights of way, narrow county roads, village streets, etc., the spreading base would not be allowed, and resort would have to be made to steel poles, which for the same strain and height would have to be more expensive.

The distance between wires is usually determined from the highest voltage which can reasonably be expected as a limit, as determined above. The rule that the distance between wires in inches equals one and one-half times the number of thousands of volts is safe so far as the striking, or repeating, distance is concerned, though to correct for arcs holding on for a time after once established would be impossible. Where the cost of erected poles is high, or the right of way expensive, two circuits per pole line should be used, and, with good wooden construction, mechanical difficulties would limit the distance between wires to at most sixty inches, which would allow a line voltage of say 50,000 or 60,000. The distance between wires is for spans not over 150 feet to 200 feet. The size of wire is determined from the load, voltage, length of line, losses allowable, etc. Five per cent. energy loss per fifty miles with sixty-cycle frequency gives a line that can be taken care of, but a smaller loss should be obtained where important lighting service is had in connection with a fluctuating load. On account of the distance and pressure, a charging current, at no load, is required of the plant, which at sixty cycles and one line 100 miles long, or thirty cycles and two lines, would require a generator as large as 2000 kilowatts, so that, unless more than this capacity had to be delivered as load, the system would not be economical. In order to be perfectly flexible, this amount of power would have to be carried over one circuit. The wire would, therefore, be large enough for mechanical reasons, and the energy loss per insulator, or per unit length, would be negligible, except, perhaps, for voltages over 60,000.

There is one plant in operation which, if the energy loss per insulator, or unit length, was as much as calculated from experiments, it would not be able to deliver load.

In stringing the conductors, especially if they are of aluminum, attention must be given to the temperature at the time the wires are tied in. This might seem to many to be a useless and tedious process; but a set of curves showing the sags for given spans and temperatures, in the hands of a careful line foreman, will give a line good in appearance, and at all times safe from overstrains. It is not so important to know what the maximum sag for maximum temperature will be, as the maximum strain at lowest temperature, with sleet, if any, taken into account. Aluminum cables are made which are as strong as copper for the same conductivity. When conductors are given the proper sag, a given safe tension can be maintained for longer spans than would ordinarily be used in transmission work. There are a number of spans over 600 feet in length, and have been in operation for two or three years. These have been closely watched during windstorms, to see what deflection would be given to the wires. Three aluminum cables seven-eighths of an inch in diameter, 600 feet span, nineteen feet sag, were deflected from 30 degrees to 45 degrees from the vertical by a wind that was estimated to be seventy miles per hour. All three conductors kept their relative position when deflected, and there were no perceptible waves or vibrations in the cables.

It is claimed by some who have had the opportunity to notice that in longer spans there is less tremor, vibrations or waves passing over the span when there is a wind than when there is none.

Observations of the writers show that, for spans of 600 feet at least, there is no tendency of the wires to swing together in ordinary storms. Tornadoes would no doubt twist the wires together, but that would not be the worst damage done.*

* It is frequently stated by some engineers that a three-phase circuit should be strung with the base of the equilateral triangle on top in order to prevent more than one phase being shortened by wires being thrown over the circuit, and in order that synchronous motors will continue to operate until they can be thrown on to another circuit.

If a sketch is made of either a star or delta circuit, and a wire shown across two of the circuit wires, it will be seen that two of the phases instead of one will be shortened, and that what remains is a modified single-phase, with varying constants depending upon the resistance and the swing of the shorting wire.

It has been observed. under the conditions, that a synchronous motor will, if carrying load, immediately fall out of step. For mechanical reasons, it would be better to place the apex at the top in order to reduce the pull from tie pole top, and for electrical reasons, it would be as well, since the men in charge of the line cannot be present to select the kind and length of wire that is to be thrown over the circuit.—J. F. K. AND A. C. B.

The height of pole and towers would depend upon the sag and whether or not the telephone circuit was strung underneath. With spans of 660 feet, the sag for aluminum would be about twenty feet, and with a telephone circuit six feet below, a sixty-five-foot tower would give a clearance below the telephone wires of twenty-nine feet.

A clearance of thirty-five feet below the lowest power wires is little enough for places where a house or derrick is liable to be taken under.

The frequency to be adopted depends upon whether the power is to be supplied to already installed apparatus of a given frequency. For long lines, a frequency of over sixty cycles will give a regulation difficult to allow for. The lower the frequency the better will be the regulation of a line for a given load, the smaller will be the generator capacity required to charge the line, and the voltage drop will more nearly approach the *IR* of the circuit. For a given line, there is only one particular value of current where the condensance of the line will be neutralized by the inductance; so that this fact also decreases in importance. The swing of the power factor at the power house will not be so great and the point of maximum power factor will be nearer full load. For a new system, or where possible, over thirty cycles should not be used.

With the general use of alternating current railway motors, fifteen cycles or less may be advisable.

The power wires of a single or double circuit line should be transposed with reference to the power taps and talking points.

Experiment has shown that transportations at stated distances need not be made and may not give as good results as the first method. With two circuits, one should be transposed in the opposite direction to the other; although there is one double circuit line operating satisfactorily as far as the telephone is concerned, with one of the circuits run straight through. Experiments made with a power line without transpositions and a telephone transposed every fifth mile, placed five feet below the power wires, gave a pressure to ground of from 2100 volts to 2800 volts when the line pressure was 40,000 volts. With 30,000 volts, the telephone voltage to ground was reduced in the same ratio.

By giving the power wires two-thirds of a rotation between power taps and talking points, this voltage was not readable on a Weston or hot-wire 150-volt voltmeter. The induced voltage was was due to capacity, and in none of the tests was there any measureable electro-magnetically induced voltage.

The large number of fatal accidents which have occurred in the past from the telephone circuit being placed on the same poles with and under the power wire, would warrant a separate pole-line, even if the service were no better.

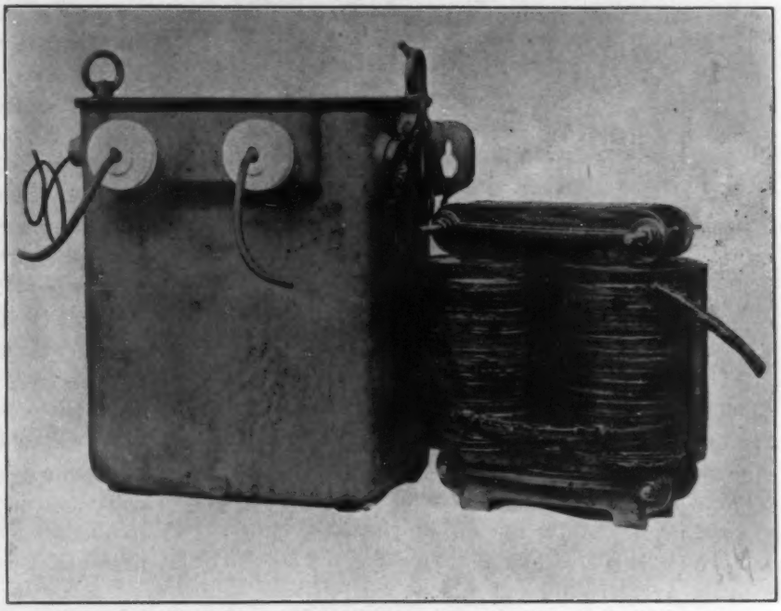
A telephone is most needed at times of line disturbances, and at such times it is rarely of service. The induced voltage on a telephone circuit, even where power line transpositions are made, when one or more of the power lines are out or grounded, is high enough to be dangerous to life and to set fire to adjacent woodwork. The distance between the two circuits should be at least six feet, and eight feet would be better. In stringing the telephone wires, the same sag should be given as to the power wires. For lines over fifty miles in length, copper or aluminum should be used instead of the regulation No. 9 BB.

The question of high tension switches and circuit breakers is one of the most important in the operation of a system. They should be of the most approved design only, and placed at both ends of a circuit and at intermediate, or cross-over, points. All poles of a three-phase switch, or breaker, should work together and not singly. A switch which tests satisfactorily in the shop may not operate in service; so that it should be placed in position and opened ten or more times under the most severe conditions with which it is likely to meet, before it is pronounced safe. All breakers and switches should be provided with cut-out switches on each side, so that they can be taken out of a live circuit for repairs.

NEW POTENTIAL TRANSFORMERS FOR USE ON HIGH TENSION CIRCUITS.

BY EMILE GUARINI.

MESSRS. FERRANTI, Ltd., electrical engineers, Hollinwood, Lancashire, have recently built some very interesting transformers intended for use in conjunction with low tension instruments, as wattmeters, voltmeters, synchronizers, relays, etc., on high potential circuits. The secondary winding is designed for a standard pressure of 100 volts. Any other secondary voltage below this, or up to 290 volts, can be supplied. They are guaranteed to withstand a test pressure of twice the working voltage for any length of time, and a pressure equal to three times the working pressure for one minute. The greatest possible care is taken with the insulation of these transformers. They are all dried in vacuo and impregnated with insulating compound at several different stages of their manufacture. Above 5000 volts the transformers are oil-insulated and cooled. The transformers can be used with any voltmeter, wattmeter or relay. They can also be used for operating synchronizers, as the greatest temperature rise of the transformers, after giving 180 watts for one hour, does not exceed 50 degrees Fahrenheit. It must be understood that the synchronizer is not permanently connected to the transformer, but only during the time required for synchronizing. This is of importance, as the increase load on the transformer, due to the synchronizing current, may alter slightly the ratio of transformation, and thereby introduce a small error into the wattmeter readings. This error, however, is negligible, as the synchronizer is only connected for a few minutes during the day.



FERRENTI'S TRANSFORMER FOR LOW TENSION INSTRUMENTS ON HIGH POTENTIAL CIRCUITS

It is now generally acknowledged that this system of measuring is preferable to that in which the indicating instrument is connected directly in the high potential line. A precaution which should always be observed is to connect the low tension winding of the transformer to earth. It is then impossible for any part of the indicating instrument to be more than about 100 volts above earth potential. To this end, in all these instrument transformers, one end of the low tension secondary is connected to the case, and a holding-down screw is provided on the latter, by means of which an earth wire can be connected thereto. An insulated brush is also provided, as well as this arrangement, so that, if desired, the leads from the secondary winding can be brought away from the transformer without earthing one of them.

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EDITORIAL.

ANENT THE GAS ENGINEER

The criticism of gas engineering methods which appeared in these columns for October, promptly brought out some very praiseworthy communications to the editor from JOURNAL readers. One, whose name is very familiar to the gas and engineering fraternities of the West, states:

"The leading editorial for October is just a little bit strenuous, yet I think it is all right. Of course there is a great difference between electrical and gas science in that in dealing with electrical matters you are handling physical forces, immutable in their nature, capable of exact measurement, and responding to generally understood and invariable laws, while in gas making you have to deal with the most obscure and complicated problems of that most complicated and obscure subject, organic chemistry. I suppose that there is really no difference in kind, but there is undoubtedly a great difference in degree of difficulty, when you compare the manipulation and measurement of electrical manifestations and forces with the same or similar measurements, etc., of chemical reactions between complicated organic substances, where the product of the reaction, both as to nature and as to quantity, is effected by innumerable graduations of temperature, pressure and rapidity of flow, by the character of heating and cooling surfaces, and many other conditions known and unknown.

"In other words, while I do not doubt for a moment that chemical reactions of every nature are governed by immutable laws, and that the knowledge of these laws, could the human mind grasp them all, would enable the possessor to predict the output of a gas generator as you can predetermine the output of a dynamo, yet there is no question that the laws relating to electricity are simplicity itself when compared to the infinitely complicated laws governing organic reactions. The most advanced chemical research of to-day is very largely a matter of cut and try when turned into such channels as this.

"Perhaps I do not make myself very clear. What I mean, in short, is that if one were disposed to be very critical, your remarks are hardly fair to the gas engineer, yet in general I think their effect will be good. There can be no question that if not merely the gas business, but other lines of similar nature, would devote a little more attention to the abstract side of their business, it would be to their profit in the long run, even though they might not be able to show the results in the first year's balance sheet."

Another engineer of prominence, writes:

"I have read the leading editorial in your October issue with great satisfaction, and I must say that every statement made therein is a truism. It is destined to call forth a good deal of talk on the subject, I am sure.

"Nothing is truer than the information contained in that portion of the editorial which states: 'Given an electrical appliance of a fixed design and it will perform its alloted duty without reference to the personal equation to its operator, and this duty will be done at an extremely high efficiency. As much can by no means be said of gas—that industry which is as innocent of absolute standards as it is of high efficiencies, and the operation of which depends upon the skill or whim of a *genus homo*, who generally does not know a thermal unit from a bar photometer.'

"I will add here that if this Peruvian, whose 'botanical' name is *genus homo*, has an astigmatic eye, he is liable to carry generator heats that will cause serious trouble with the gas, producing an abnormal deposit of naphthaline in the district.

"If, on the other hand, his eyesight causes him to think his heats are too high, he will get poor results with the oil and clog the machine.

"As far as the wasteful methods of even the best crude oil gas machine are concerned, it is very evident that vast improvements can be made in the method of manufacture over those in vogue at the present time. Take for instance, an apparatus that will manufacture a gas of 620 British thermal units per cubic foot which amounts to 620,000 British thermal units in a thousand cubic feet of gas, this from ten gallons of oil 14° B. gravity, weighing about 80 pounds, and having a heating value of 18,000 British thermal units per pound, which is 1,440,000 British thermal units. From this you will readily see that less than one-half of the heating value of the oil is transferred to the gas, the other 820,000 British thermal units is either lost or contained in the lamp-black which forms a residue from this process of manufacture.

"It is needless for me to go on in this strain at the present time, for as I have stated before, your editorial covers all these things in a general way."

Verily, there is room for improvements in gas engineering methods.

THE ELECTRICAL CONGRESS

Much of the great importance to transmission engineering transpired during the week beginning September 12th, when the International Electrical Congress held daily sessions in the music hall of the Coliseum at St. Louis. The Congress aside from the Chamber of Delegates consisted of eight sections and although only one of these sections, namely section D, was devoted to electric power transmission, nearly all of them contained papers and discussions having a more or less bearing upon this industry. Space will not permit a review of all the papers which were of a tendency bearing upon transmission enterprises for they alone will form an extensive volume. They should, however, form a subject of a very brief review in these columns.

Section D. held four sessions under the chairmanship of Mr. Chas. F. Scott, Dr. Louis Bell acting as permanent secretary. To the latter we are indebted for a brief, though graphic description* of the proceedings of the Congress. Between the lines he pays compliments of a dubious nature to the management of the Congress in stating that the strenuous sessions of Section D. were located in the same dingy vaulted room with the electric lighting section, and as the only separation between them was a line of flags draped a few feet from the floor, the discussions of the two sections were so hopelessly mixed up that the chap with the most sonorous voice fared best in the stenographer's report. On the whole, however, he regards the papers as being valuable and the discussion, when audible, as rather illuminating. One of the most striking things in running back over the proceedings is the almost complete absence of any reference to transmissions at 10,000 volts or less. In fact, the whole work of the section centered on pressures from 30,000 volts up.

"Perhaps," says Dr. Bell, "the paper which attracted most attention was Prof. F. G. Baum's on high-pressure long-distance lines with special reference to the Bay Counties and Standard lines now consolidated with several others in the California Gas and Electric corporation. The paper is notable as an extension of Professor Baum's already-published papers on the practical calculation of transmision lines, and it certainly contains more of practical value on that topic than anything in similar compass with which the writer is acquainted. Among other things the serious question of resonance is taken up, especially the special case known as surging, and a very pretty approximate formula for the possible rise of current is presented. It is simply this, that the voltage rise is two hundred times the broken current in amperes. The very important conclusion which Professor Baum drew from this was that for equal energy, the higher the voltage the less the danger from surging. It may be news, by the way, to mention that at one period the Bay Counties' plant for several weeks supplied customers over 350 miles of circuit, with entire success. The whole paper was full of valuable data, but the author of it stirred up a hornet's nest when he brought out the fact that he had practically abandoned lightning arresters, using only the horn type with wide gaps, and considered even these rather needless when using 60,000 volts or so. This brought up on their feet divers harassed victims of lightning, and for a few minutes the section room sizzled. After order was restored it became apparent, first, that on Professor Baum's system lightning is a rarity anyhow; second, that when one is insulated for 60,000 volts with everything like a decent factor of safety, he is pretty well insulated against the second-rate minor lightning discharges that work havoc on a low-tension line; third, that it is sometimes better to take trivial chances of a short-circuit from a first-class thunderbolt than to be in constant trouble from delicately set arresters that work too often. But the engineers in the lightning country were willing to take no such chances, and intimated that if the author of the paper had been up against the real thing in lightning, he would change his mind."

And possibly he will, for it is a significant commentary to state that as these lines are written, a brief press dispatch from Woodland, in Yolo County, California, is received, announcing the destruction of the transformers in the sub-station of the Woodland Gas & Electric Company as a result of lightning. This, however, is an infrequent occurrence, but as the lesser ill should always be chosen, it is probably better to lose a transformer now and then by reason of no lightning protection than to suffer frequent interruptions that are directly traceable to arrester discharges from purely artificial causes. Again the truth can not be gain-said that local conditions must prevail in the determination of engineering practices, and perhaps in no case is this truism of greater significance than in the case of lightning.

The proceedings of the Congress were of such scope as to make them take rank among the classics of engineering literature, and the power transmission fraternity will appreciate this when the time comes for them to have the privilege of perusing those papers which specially pertain to their fields. Prominent among them will be found that of Eastman on the "Protection and Control of Large High Tension Alternating Current Distributing Systems"; of Berhand on "The Testing of Alternating Current Generators"; of Steinmetz on "Alternating Current Motors"; of Lincoln on "Transmission and Distribution

Electrical Review (New York), Volume XLV, September 17, 1904.

Problems Peculiar to the Single-Phase Railway"; of Baum on "High Potential Long Distance Transmission and Control"; of Perrine on "American Practice in High Tension Line Construction"; of Smith on "Experiments With Transformers for Very High Potentials"; of Stern on "The Superiority of Alternating Current for the Supply of Large Cities"; of Torchio on "Distributing Systems from the Standpoints of Theory and Practice"; of Ryan on "Elements in the Design of High Pressure Installation"; of Kelly and Bunker on "Difficulties in High Tension Transmission and Methods of Mitigating Them"; of Geary on "The Construction and Installation of High Tension Transmission Lines"; of Blackwell on "Conductors for Long Spans"; of Rasch on "The Buffer Machine, or Booster, in Traction Service and Its Proper Regulation"; of Rushmore on "The Regulation of Alternators"; of Hancock on "The Bay Counties' Power Transmission System"; and of Hayward on "Practical Experiences in the Operation of Many Power Plants in Parallel."'

Of these papers, those of Mr. Baum, Dr. Perrine, and Messrs. Kelly and Bunker, are presented in full in this issue. Dr. Perrine's paper is of value in that it embodies a succinct resume of the best American practice in high tension line construction and operation. In the matter of choice of voltage he endorses the rule which provides for the use of 1000 volts per mile, provided the length of transmission be not above 60 miles, since above 60,000 volts no commercial work has been regularly operated. As to switching, the author regards both the horizontal and vertical break type of oil switches as being standard. He gives no preference to the horizontal switch, although he believes that in the future it will become standard for the highest potentials. For transmission at less than 25,000 volts, the delta connection of transformers is preferable, but above this value he states that the star connection should be used. In the matter of conducting materials, of which only copper and aluminum are available, the prference between them is almost entirely a matter of cost, and finally lightning arresters for use on lines carrying voltages in excess of 25,000 are not regarded as thoroughly satisfactory.

A paper of this character, being confined to the narration of fact, requires no detailed discussion, and particularly is this true when it comes from the pen of one who is as thoroughly conversant with the latest and best practices in long-distance high tension transmission work as is the author.

The paper by Messrs. Kelly and Bunker bears the refreshing and wholesome stamp of absolute truth and frankness. Would that all engineers were as free and untrammeled as are they in their utterances. This suggests the idea that were the history of transmission enterprise in the great West written from the standpoint of plain, unvarnished fact, "the seamy side of transmission" as a worthy contemporary has termed it, would be ventilated in a way that while it might cause present heartburns, would surely result in no distant day in positive blessings. The glossing over of engineering troubles can not always prevail, so may the day be hastened when the truth shall always be spoken as ably and as frankly as Messrs. Kelly and Bunker have uttered it.

ALLIS-CHALMERS CAPTURES EVERYTHING

As the forms for this issue are being made up, a telegram is received from Mr. Arthur Warren, manager of the Department of Publicity of the Allis-Chalmers Co., Milwaukee, Wis., conveying the information that the Allis-Chalmers interests have won the distinction of the highest honors that are to be bestowed by the Louisiana Purchase Commission for the exhibits of power engineering appliances made at the St. Louis Exposition. It is then in order to extend congratulations to the Allis-Chalmers Co., for the laurels it has won will at least awaken in the breast of every station manager and independent engineer a feeling of quiet, yet superlative satisfaction in the knowledge that by this victory electrical interests the knowledge that by this victory electrical machinery hitherto considered of secondary moment have been lifted at one stroke to the very first plane of importance. In fact, the Allis-Chalmers and Bullock interests have won an engineering triumph that has never been equaled.

But let the telegram speak for itself:

"The Allis-Chalmers and Bullock interests having won the highest awards at the St. Louis Exposition, have swept the field. They have taken the grand prize in every department—steam engines, electricity, and mining machinery—also the gold medal for the Bullock system of operating variable-speed electric motors for driving machinery. One grand prize was given for the Allis-Chalmers 'Big Reliable' Engine,' which is the largest ever seen on exhibition. Another grand prize was bestowed for our Bullock electric generator, these two machines comprising the high duty unit which supplies the world-famous decorative lighting and much of the power consumed at the St. Louis Exposition. Another grand prize was given us for our exhibit in the Department if Mines and Metallurgy. In fact there is no trophy left to be won for we have taken everything."

FAVORING PORTLAND AS A CONVENTION CITY.

EIGHT prominent members of the American Society of Civil Engineers, in response to a circular issued by its secretary calling on members to designate their choice of localities for holding the next annual convention of this society, have issued the following to all members, in commendation of Portland as a meeting place during the period of the Lewis and Clark Centennial Exposition, in 1905:

We believe it will be an interesting and valuable incident in the history of the society to have that convention held in the city of Portland, Or., the year 1905 being the centennial anniversary of the grand expedition of exploration of Lewis and Clark, sent forth by President Jefferson, and which crossed from the headwaters of the Missouri River to the headwaters of the Columbia and followed its course to the Pacific Ocean.

Portland, indorsed by the Government of the State and the United States Government, with many of the States of the Union, will hold an international exposition, the object of which shall be to celebrate the historical event and illustrate the value of the Pacific Basin to the commerce of modern civilization.

We, therefore, invite our colleagues of the society, neighbors of the Pacific Coast, to designate Portland as their choice in

selecting a place for the annual convention of the society for 1905, promising, on our part, to do all in our power to make the occasion one of the highest pleasure and profitable instruction; efforts that are promised the assistance and co-operation of the State and city governments, and the Centennial Exposition.

REFERRING TO "THE JOURNAL'S" GAS PUBLICATIONS.

W. B. Cline, president Los Angeles Electric Company, writes: "I am heartily in sympathy with your efforts to give gas engineering the journalistic prominence which its importance merits."

C. F. Adams, president Portland Gas Light Company: "I am very much pleased, indeed, to see THE JOURNAL take up the subject of gas, and trust that it will be upon the same lines as has marked the progress of this paper in the field of electrical transmission."

M. V. McQuigg, president of the Monterey County Gas and Electric Company: "Your description of the gas plants of our company is remarkably well written."

W. H. P. Hill, superintendent at Salinas for the Monterey County Gas and Electric Company: "Your deecription of the apparatus of the Salinas Gas Works is splendid."

A JOINT CONVENTION IN SAN FRANCISCO.

AN innovation in the way of an enginnering convention is to be held in San Francisco during the first three days of December next, under the auspices of the Technical Society of the Pacific, this convention being an elaboration of the usual fall meeting of the society named. It is proposed to make this gathering of such a general nature that all kindred engineering societies hereabouts may participate, and more particularly will this be the case with those associations which are devoted to electrical technology. Prominent among these participating societies will be, therefore, the local membership of the American Institute of Electrical Engineers, as well as the Pacific Coast Electric Transmission Association.

The preliminary programme for the convention has been arranged on the following lines: All meetings will be held in the library building of the Mechanics' Institute, No. 31 Post Street, San Francisco. On Thursday evening, December 1st, George W. Dickie, president of the Technical Society, will open the conventian with an introductory address of welcome, after which Robert McF. Doble will deliver a lecture, to be illustrated by numerous lantern slides, on "Hydro-electric Power Development and Transmission in California." On the following afternoon (Friday) George W. Nichols will lecture on "Water Power and Electricity in California," after which Frank P. Medina will read a paper on "Engineering and the Law." On Friday evening papers will be read by John Richards on "Phenomena of Machine Operation," and E. T. Hewitt on "Trade Schools, Their Importance." Papers as follows will be presented Saturday afternoon: "Fuel Oils, Their Physical Properties," by P. W. Prutzman; "Durability of Materials of Masonry used in San Francisco," by Marsden Manson; "Reclamation of Harbor Marshes in Tidal Basins," by Otto Von Gelden.

On Saturday evening a banquet will be given for the purpose of bringing together all the technical friends and their ladies to foster good-fellowship, to renew old acquaintances and make new ones. In particular, ladies are invited to all functions at all times, and, if it is possible to accomplish it, one of the afternoon sessions will be held at the Tavern of Tamalpais, on Mount Tamalpais. Full details of arrangements are to be made later, these details being in the hands of committee consisting of Messrs. Connick and Von Gelden, as a general committee to provide for the place of meeting and to care for all attendant details, and Messrs. Uhlig and Schild as a committee on banquet and possible excursions. In this convention the co-operation of all electrical men is earnestly solicited for the efforts that are to be exerted are aimed to result in permanent benefits to the engineering profession at large.

LITERATURE.

"SELF-PROPELLED VEHICLES," a practical treatise, with illustrations, by J. E. Homans, A. M.; 8vo., pp. 672, bound in black vellum, gilt top. gold titles. Theo. Audel & Co., Educational Booksellers, New York. Price, $2.00.

In presenting the new edition of this work, the publishers announce that the book has been thoroughly revised and in large part rewritten. There is a vast amount of useful information packed into its 672 pages, and it is so well arranged and so clearly stated that the reader cannot fail to find and comprehend the information given.

The general principles of automobile construction and operation, including steering devices, under-frames, wheels, tires, bearings and lubricators, are included in the opening chapters. Then follows an exhaustive account of the theory, construction and operation of gas engines, occupying over 100 pages. Several typical engines are taken up and discussed separately, and their properties, as regards balance, speed and power, are discussed in the light of fundamental principles. The explanations of the governing principles are clear and valuable, while the discussion of ignition, including the hot-tube and the primary and secondary sparks, cannot fail to prove of the utmost value.

Probably the most interesting feature of the entire work is the extensive chapter devoted to the description of leading types of gasoline vehicles, including the most important of American build. In this chapter the reader is informed as to the details of the transmission and control apparatus in each case. The chapters on electric vehicles are also full and certain to prove of practical use to the owner and chauffeur. Taking the subject of electrical apparatus from the fundamental principles of circuits and batteries, the discussion passes to the theory and operation of generators and motors, the laws of motor operation, the laws involved in computations of speed and power, and the varieties of motor suited to road carriages. Electricity meters are described and illustrated in a brief chapter, and the principles underlying storage batteries, their construction and care, are outlined.

All necessary information is given, and the merits of several types of steam carriage are fully set forth. The book closes with a chapter on "Gasoline Vehicle Management," excellent for its completeness and "useful hints"; another on gasoline cycles that covers the general principles involved in this type of motor. An exceedingly full index at the close of the book puts its contents into "ready reference" shape, an advantage of no small importance in view of contingencies sometimes happening in the use of the automobile.

'GAS AND OIL ENGINE MANAGEMENT," a practical guide for users and attendants, by M. Powis Ball. Price, $1.00. Published by J. B. Lippincott Company, Philadelphia, 1903.

A small unillustrated volume of 110 pages, intended for non-technical readers. It does not treat of the theory of the engine at all, but gives in clear, concise language the points which should guide in the selection of an engine, precautions that should be taken in its installation and operation, and gives a number of the more usual troubles experienced, with causes and means of setting them right. A book well worthy of purchasers and operators of small gas or oil engines.

"THE DESIGN AND CONSTRUCTION OF OIL ENGINES," by A. H. Goldingham, M. E. Ilustrated, 254 pages and 107 illustrations, second edition, revised and enlarged. Published by Spon & Chamberlain, New York, 1904. Price, $2.00.

The scope of the book is limited to "oil engines," or, as the author states, "the term oil engine refers here only to those engines using as fuel ordinary kerosene, or the crude and inferior heavy grades of petroleum of specific gravity .79 to .85." The book shows evident familiarity with the subject, and is a very timely one in view of the rapid growth of interest in the subject. Design of mechanical features is treated quite fully, with formulæ for proportioning various parts of the mechanism, but the book

would have greater value if it had one or more chapters on the thermel principles involved, and the proportioning of cylinder volumes for given powers. While a limited amount of catalog illustrations and information are given, they are such a minor quantity that they do not mar the book as a whole. Testing is quite fully treated and forms a valuable feature. The composition of the book is excellent, as well as the line drawings, but the half-tones of engines are rather poor. On the whole, a worthy addition to the mechanical engineer's library.

"ALTERNATING CURRENT ENGINEERING PRACTICALLY TREATED," by E. B. Raymond, testing department General Electric Company, Schnectady. Freely illustrated, 232 pages. Published by D. Van Nostrand Company, New York. Price, $2.50.

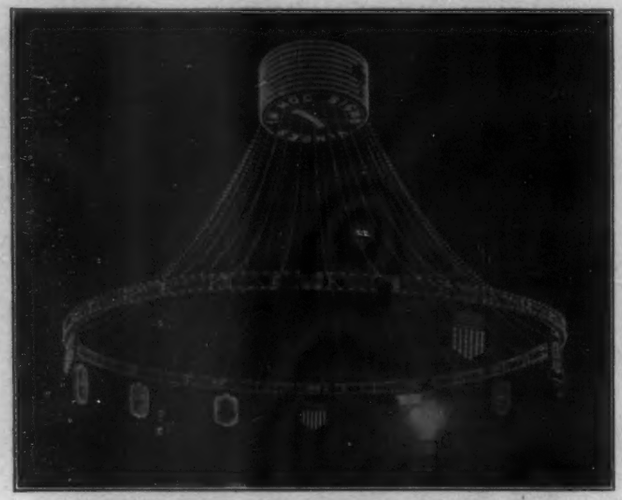
This is one of the best books that have appeared in recent years, giving a general treatment of alternating current engineering, presented in a practical way, without complex methods of explanation and free from any matters not bearing directly on purely engineering work. The book has been written, covering the subject without the use of calculus. The first part is devoted to an explanation of the general laws of magnetism and alternating currents. The second part deals directly with modern alternating apparatus, covering in a general way the principles of design and operation, and in detail the methods of test that have been found to be the best. It is entirely free from catalog matter, and is well adapted for use as a text book in electrical courses, and can be read with advantage by engineers generally.

THE ELCTRICAL DECORATION OF SAN FRANCISCO.

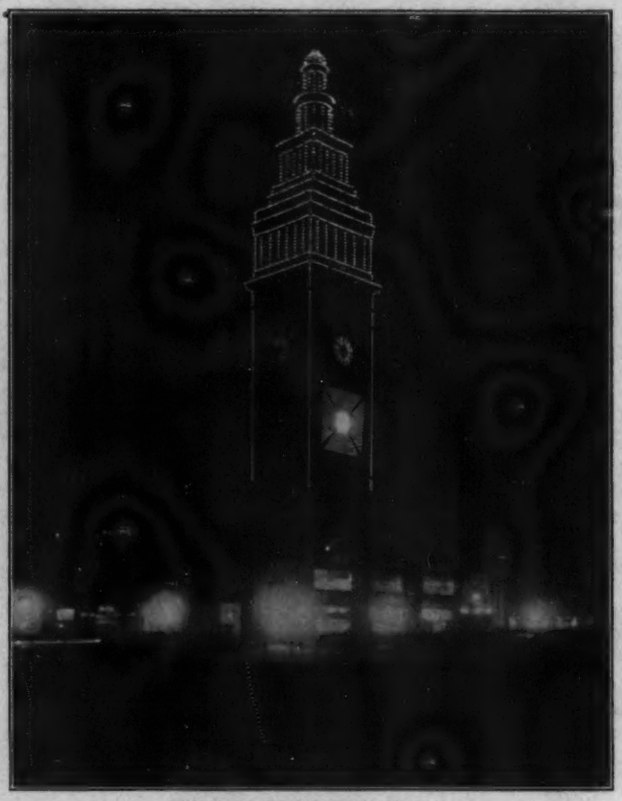
PART I

SAN FRANCISCO'S lavishness in the electrical decoration of its streets and buildings during periods of civil or fraternal celebrations has given it just renown, for without doubt its enterprise in this direction finds no parallel. In this serial the more prominent of these illuminations will receive consideration, and details will be given of the various engineering difficulties encountered as well as the means that were adopted for overcoming them.

The decorative illuminations that were used in the Knights Templar Conclave consisted naturally of Masonic emblems, prominent among which were the square and compass of the Blue Lodge, the keystone of the Royal Arch Chapter, the red cross typifying the order of the Red Cross and the Maltese cross emblematic of the orders of the Temple and of Malta, the double bar of the Grand Commandery of the State, the triple bar of the Grand Encampment of the United States, the British Jack prominently displayed in honor of the visit of the Earl of Euston and his fellow knightly subjects of King Edward VII, American shields displayed for patriotic purposes, coats of arms of various commanderies, and particularly those of California and Golden Gate Commanderies, the Passion Cross typifying the crucifixion, five-pointed stars emblematic of the Order of Eastern Star and other emblems of minor import.



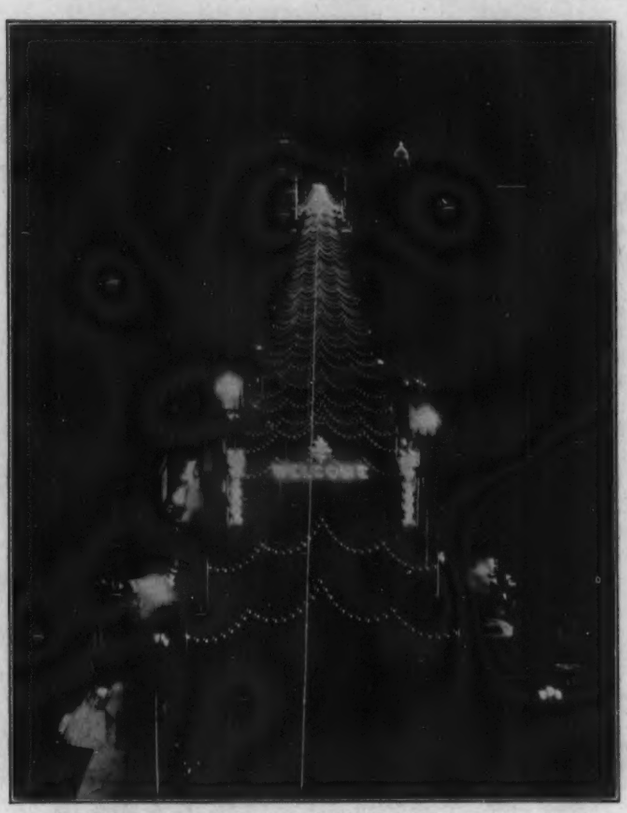
THE GREAT KNIGHTS TEMPLAR BELL OVER LOTTA'S FOUNTAIN



THE TOWER OF THE FERRY BUILDING

As is almost invariably the case in San Francisco, the majority of electrically lighted emblems of a decorative nature were the product of the Novelty Sign Company, which engages in this class of work more exclusively than any other concern of the West. The largest installation of this class was that with which the great bell over Lotta's fountain was decorated. Within the bell and at its top was perhaps the most striking feature of the entire display, consisting of a disk twenty-five feet in diameter, on which was displayed the traditional cross and crown in colored lights, about which were two rows of lights containing the sign in circular form, "*In Hoc Signo Vinces*," in twenty-four-inch electric letters. The bell was surmounted by a cylinder of light twenty feet in diameter and sixteen feet high, on the opposite sides of which, facing up and down Market street, was placed a Passion cross in red electric lights. The ninety-foot ring forming the lower rim of the bell supported a number of double-sided emblems, each of which was of the uniform height of eight feet, and among these emblems were the square and compass, the keystone, the red cross, the Maltese cross, the double and the triple bars, the British Jack, three American shields, the coat of arms of the Golden Gate Commandery and a Greek cross, all being presented in their traditional colors. In all about 2000 lights were used in the construction of the emblematic designs which appeared on the bell.

Prominent among the other striking installations of the Novelty Sign Company was a ten-foot Grand Encampment double cross in purple, which supported the word "Welcome" in four-foot reflector electric letters" in such a way that, with the side pillars placed at the curbs of the street, formed an arch of welcome to all who entered the city by way of the ferries at the foot of Market street. At the colonnade at Market street, near Fifth, the emblematic decorations consisted of five double-sided Maltese crosses,



FROM THE FERRY TOWER, LOOKING UP MARKET STREET TO THIRD STREET

one of which had a height of six feet, while the remaining four were each four feet high. At *The Examiner* building, where some 2600 sixteen-candle-power incandescent lamps were used, the principal feature consisted of a mounted knight of heroic size worked out in various colored electric lights, white and dark red predominating. This figure, which was of official design, was twenty feet high by sixteen feet wide. Above it in three-foot electric letters appeared the word "Welcome," while below it was erected an eight-foot electric American shield. At either side and below the mounted knight was placed a six-foot Maltese cross. On the Third-street side of the building was an eight-foot Passion cross, while on its Market-street face, at the center, appeared an eighteen-foot emblem, consisting of the official badge of the Twenty-ninth Triennial Conclave worked in suitably colored incandescents. Below and on either side of this badge were shown the five-pointed stars that are emblematic of the Order of the Eastern Star.

Some 3000 sixteen-candle-power incandescent lamps were used in the illumination of the Masonic Temple, on the corner of Montgomery and Post streets. At the corner between the first and second stories was a twenty-foot Maltese cross, while above it on the level of the third story appeared the emblematic square, compass and "G" in electric letters twenty-feet high over all. In each of the four windows of the second story there was an eight-foot Passion Cross, and in different positions on the Post-street side of the building were Scottish Rite emblems—a keystone and an Eastern Star.

The front of the R. D. Davis building carried a twelve-foot Maltese cross and a cross and crown four feet high above it, making a combined emblem that measured sixteen-feet over all. At Hale's the principal decorative features consisted of the mottoes "Welcome Sir Knights" and "*In Hoc Signo Vinces*," worked in three-foot electric letters, as well as a ten-foot red cross, together with a mounted Knight overlooking the Golden Gate. At Armand Cailleau's was a twelve-foot Maltese cross; at Koenig's a four-foot Maltese cross over the doorway, with a red cross and the Grand Encampment badge in the respective windows; at Newman & Levinson's, a sign, "Welcome Knights Templar," in two-foot letters and four five-foot Maltese crosses; at Vanderslice's, a six-foot Maltese cross in the doorway and a Passion cross and a Grand Encampment cross, each four feet high, in respective windows. At the White House the entire outlines of the building, including the various floors, were traced in eight-candle-power lamps, but this work, however, was installed by the Century Electric Company.

These are among the most prominent of the decorative installations installed by the Novelty Sign Company in the retail district, but beyond them notworthy installations were made at Golden Gate Hall, at the Hopkins-Searles Art Gallery and the Mechanics' Pavilion. Golden Gate Hall was used as the headquarters of the Grand Encampment of the United States, as well as of the Golden Gate Commandery, and the Sutter-street front of the building was outlined with approximately 500 sixteen-candle-power lamps. A twelve-foot Maltese cross occupied the position of honor in the front of the building; over the doorway was a five- foot Passion cross; across the street was suspended a double-sided sign, "Golden Gate Commandery, No. 16," in thirty-inch electric letters, above which was supported a six-foot double-sided Grand Encampment cross. The interior electric decoration within the hall consisted of a twelve-inch sign supported over the stage and reading "Golden Gate Commandery, No. 16." Two similar signs were at the Hopkins-Searles Art Gallery, one being outside of the building and the other being in the main exhibition hall, across its south end, in the form of a semi-circle, where was also displayed a five-foot Maltese cross. The Larkin-street frontage of the Mechanics' Pavilion carried a twenty-five-foot Maltese cross over the main entrance, and across the street was suspended a double-sided electric sign in three-foot letters, reading "California Commanderies." The face of the building was outlined in 400 sixteen-candle-power lamps, and the street in front of the building was festooned with about 500 sixteen-candle-power lamps looped across it. Within the Pavilion a grand center-piece, eighteen feet in diameter and containing a cross and crown, occupied the center, while suspended from it were streamers of sixteen-candle-power lamps. Toward the west at the ceiling appeared an eighteen-foot Passion cross, surrounded by similar streamers, while at the east the ceiling was likewise relieved by an eight-foot Maltese cross with streamers. At various points around the balcony were displayed four-foot emblems, consisting mostly of the square and compass, the keystone, red and Maltese crosses and the cross and crown. The art gallery of the Pavilion, which constituted the headquarters of California Commandery, No. 1, was decorated with 400 sixteen-candle-power lamps and ten arcs. Within the Pavilion were quartered the various commanderies of the State. The entire interior of the building was literally covered with evergreens and its usual

THE KNIGHTS TEMPLAR COLLONADE, MARKET STREET, NEAR SIXTH, SAN FRANCISCO

ILLUMINATION OF THE MASONIC TEMPLE DURING THE KNIGHTS TEMPLAR CONCLAVE

barn-like appearance was lost, not only from this cause, but also from the fact that its roof was ceiled with canvas. Under the gallery, along the northern side, were arranged the various headquarters of commanderies from the northern part of California, while toward the south were those of the southern part of the State. Throughout all there prevailed a medley of signs and emblematic designs, all electrically illuminated.

PERSONAL.

Mr. F. J. Pazak, who built the telephone line of the Seattle Independent Telephone Co., Seattle, Wash,, as well as a number of systems in the East, has opened offices in the Crossley Building, San Francisco, to engage as telephone engineer and contractor.

Mr. W. E. Skinner, formerly associated with the Westinghouse Electric and Manufacturing Company, of Pittsburg, Pa., has been placed in charge of the new offices of the Canadian Westinghouse Company, Limited, of Hamilton, Canada, which have recently been established at Winnipeg, Manitoba.

Mr. E. J. Koppitz, of San Francisco, and who for many months past has held the position of engineer for the London office of the British Westinghouse Electric and Manufacturing Company, Ltd., has returned to his native country after having reaped a harvest of engineering experience in the British Isles, and is now with the superintendent of the subway division of the Interborough Rapid Transit Company, New York City.

Mr. Rudolph W. Van Norden, general superintendent of the Central California Electric Company, was married to Miss Rowena Fay Jackson, the accomplished daughter of Mrs. Nora Jackson, of Sacramento, at the Capital City, on October 12th. Mr. Van Norden is recognized by the transmission fraternity of the Pacific Slope as being one of its best informed engineers, and is most favorably known to the readers of THE JOURNAL through his contributions of engineering articles thereto. It is needless to add that his friends and acquaintances in every walk are extending to the bridal couple the well wishes that are their due.

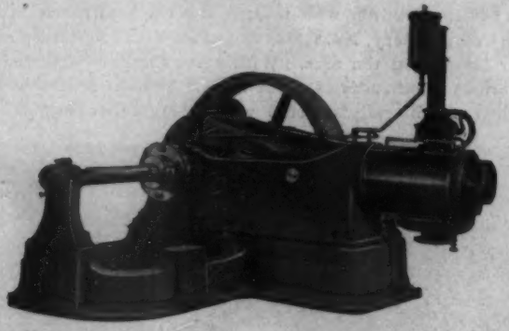
INDUSTRIAL

THE TEST OF A REEVES SIMPLE ENGINE.

BY PROFS. R. C. CARPENTER AND H. DIEDRICHS.

THE following tests of a Reeves simple engine were made at Sibley College, Cornell University, during the latter part of July and the first week of August, 1904. The purpose of the tests was to determine the steam consumption, mechanical efficiency and general behavior of the engine under various conditions of load:

As to the engine: The diameter of the cylinder is fifteen inches, the stroke fourteen inches. The steam valve is of the piston type,



REEVES SIMPLE ENGINE

taking steam at the inside and exhausting from the outside edge. Adjustments are provided whereby the ends of the valves may be expanded to stop leakage of steam, should this become necessary through wear. Both ends may be adjusted from one end, thus necessitating the taking off of only one valve chest cover. Cylinder and valve chest are well lagged. The frame is of an approved type with sub-base, the cylinder bolted on, the whole machine being an extremely rigid construction. The main bearings and the pin bearings are large, and lined with the best quality of anti-friction metal. This insures low bearing pressures and good lubrication. All of the rubbing surfaces are lubricated from a gravity central oiling system. The oil tank is fastened to the main steam pipe, and from it leads a pipe which, by branch pipes supplied with sight-feed devices, furnishes oil to the three valve guide oilers, to the main bearings, the crank-pin, and, by means of a wiper, to the wrist pin. The oil for the crank pin is taken in through a groove on each side of the crank disks, is led to the inside of the pin, and from there to the bearing. By this arrangement only one valve, that leading from the tank to the main oil pipe, needs to be handled each time. Governor pin and eccentric strap are oiled by means of grease cups. Cylinder lubrication is taken care of by sight-feed oiler and hand pump.

All of the adjustments on this machine are easily made, and, after everything was put in good shape, no trouble was experienced through heating or otherwise under any load the engine was able to carry.

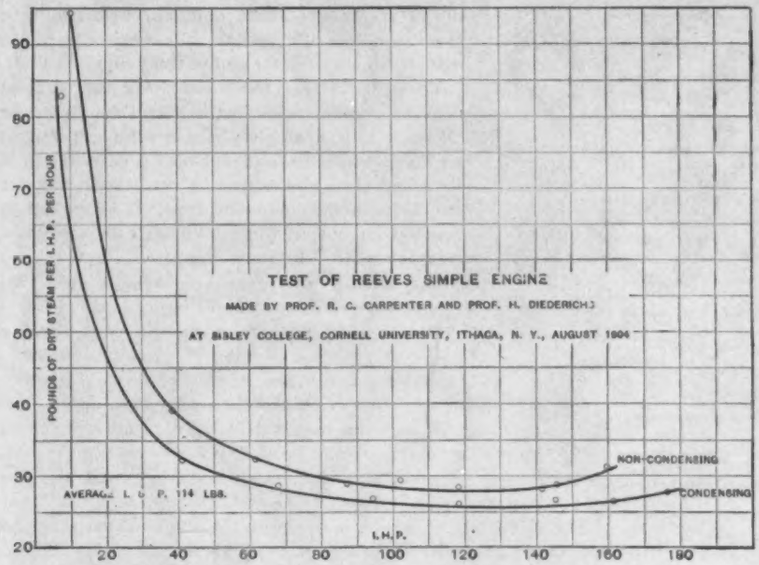
The engine was furnished with two fly-wheels for the purpose of this test. One contains the automatic governor of the Rites type, the other was used for the application of a Prony brake to furnish the desired load.

The engine was connected through about twenty-five feet of four-inch pipe to a battery of two B. & W. boilers. The machine calls for a five-inch steam pipe, but a four-inch was the largest available, so that under the high loads some wire drawing became noticeable. The exhaust was connected through about twenty feet of seven-inch pipe to a Wheeler surface condenser. The steam after being condensed was pumped by the air pump to a couple of tanks on the floor above and weighed, the steam used by the engine being thus accurately determined.

Two series of runs were made, the one non-condensing, the other condensing. For the former the air-cock on the condenser was left open, thus insuring condensation under atmospheric pressure; for the latter this was closed, and the runs were made under a vacuum as high as could be obtained. This was found to be about 23.5 inches. For each series a number of runs were made, varying from friction load to approximately 25 per cent.

overload. The duration of these runs varied from one to two hours each, depending upon the constancy of the various observations. Only one run, that of the condensing overload, was shorter, owing to signs of weakness in the brake. The observations taken were as follows:

Weight of condensed steam by weighing air pump discharge. The condenser itself was found to be tight.



INDICATED HORSEPOWER. AVERAGE INDICATED STEAM PRESSURE 114 POUNDS

The load was applied by means of a Prony brake of common design. The arm of this brake was eight feet six inches, the zero reading on the scale being forty-seven pounds. It was kept lubricated with a steady stream of cylinder oil, and kept cool by running water into the wheel rim, and scooping it out. Except for a little weakness in the arm, this brake carried the load easily. During any one run the scale was set to a certain desired weight, and the scale beam kept floating during the run.

Speed was observed by means of a continuous counter, and by hand counter as a check. The continuous counter readings were used in the computations.

A throttling calorimeter to determine the quality of steam was connected to the steam pipe just below the throttle. The quality of steam was high throughout, owing to the fact that one boiler gave superheated steam.

The other readings taken were those of steam pressure at the throttle, temperatures of injector water, inlet and outlet, and that of condensed steam. All of these readings were taken every ten minutes, except those of weight of condensed steam, for which at the high loads a change of tanks was necessary every five and sometimes every four minutes.

Indicator cards were also taken every ten minutes. The indicator used was a Thompson of the latest design. The motion was taken from the crosshead, reduction being made through a reducing wheel. Springs used were eighty pounds on all the runs but the friction condensing, where a forty-pound spring was used.

All of the observed data and the results of computations will be found on the accompanying log and result sheets. The indicated horsepower was found from the formula:

$$\text{I. H. P.} = \frac{p\,l\,a\,n}{33{,}000}$$

where p = mean effective pressure
l = piston travel in feet
a = area of piston in square inches
n = revolutions per minute

The indicator cards taken during any one run were all integrated and from the areas the mean pressures were determined. The eighty-pound spring was on calibration found to be correct, while the forty-pound spring was somewhat weak, as the attached calibration sheet shows. The last sheets of this report show sample indicator cards, one being selected from each run.

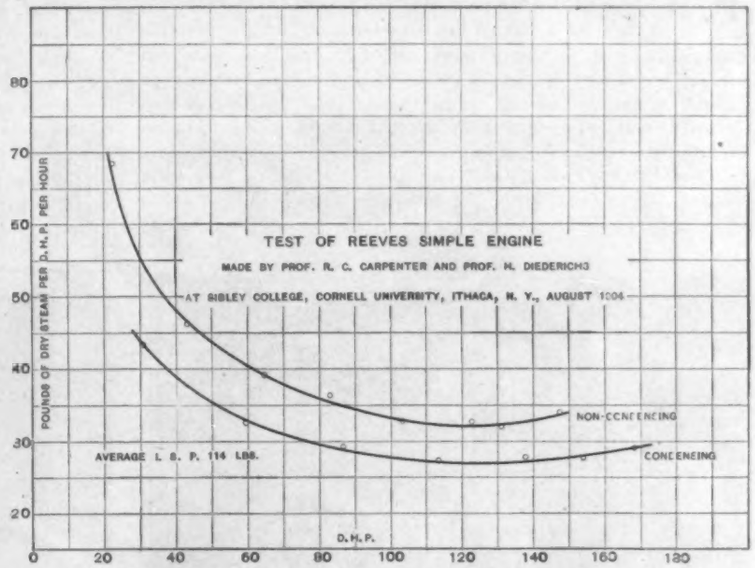
The developed horsepower was found from the formula:

$$\text{D. H. P.} = \frac{2\pi g\,a\,n}{33{,}000}$$

where g is the effective load in pounds
a is the arm of brake in feet
n is the revolutions per minute

The most important result, the steam consumption, is computed for the indicated horsepower and the developed horsepower per hour on the basis of dry steam. This, with all the other results, will be found on the attached result sheet.

In order to present the results at a glance three sheets of curves are appended. The first shows the pounds of dry steam per indicated horsepower per hour. This decreases steadily from a friction load until it reaches its minimum of about twenty-six pounds of dry steam at about 130 indicated horsepower, for the condensing runs, and about twenty-eight pounds at the same load for the non-condensing series. With a higher load there is a small increase in the steam consumption, giving about 27.5 pounds at 176.3 indicated horsepower condensing, and about 31.3 pounds for 159.2 indicated horsepower non-condensing. The remarkable part about these results is the nearly constant steam consumption of this engine on the indicated horsepower when running condensing. At eighty indicated horsepower this is about 27.2 pounds; it drops to about twenty-six pounds at 130 indicated horsepower, and rises again to 27.5 at 176.3 indicated horsepower, giving a nearly constant range from 40 per cent. underload to about 40 per cent. overload.

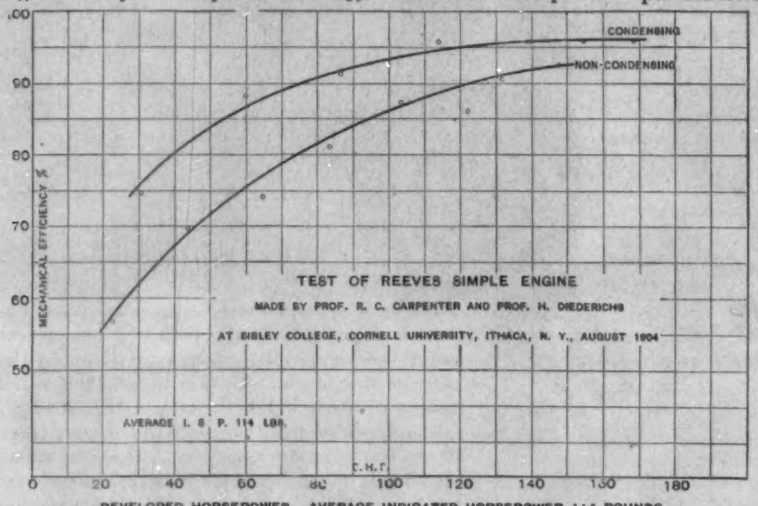


DEVELOPED HORSEPOWER. AVERAGE INDICATED STEAM PRESSURE 114 POUNDS

The second sheet shows the dry steam consumption per developed horsepower. These curves are similar to the preceding ones, the best consumption being about twenty-seven pounds at 130

developed horsepower condensing, and about 31.9 pounds at 130 developed horsepower non-condensing.

The third sheet shows the relation between the mechanical efficiency and the developed horsepower. The results are excellent. The highest efficiency reached non-condensing is 92.5 per cent. at 147.1 developed horsepower and 159.2 indicated horsepower.



DEVELOPED HORSEPOWER. AVERAGE INDICATED HORSEPOWER 114 POUNDS

For the condensing series the results are still better. The best figure is 95.8 per cent at 154.1 developed horsepower and 165 indicated horsepower, but the mechanical efficiency already reaches 90 per cent. at seventy-eight developed horsepower, reaches 95 per cent. at 133 developed horsepower, and remains nearly constant from there up to the highest load, 168.2 developed horsepower.

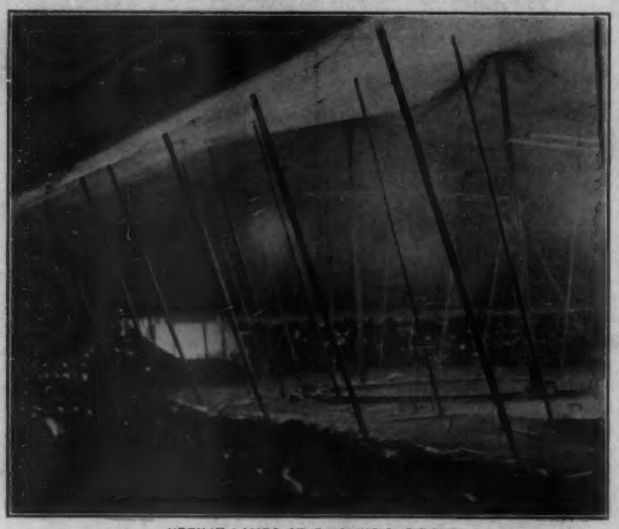
NERNST LAMPS AT THE CIRCUS.

RINGLING Brothers' famous circus, which is completing a circuit of the Pacific Coast, brings with it a novelty in the form of a Nernst lamp installation, with a portable generating plant, for the illumination of its spacious tents and surroundings. Interest in the installation is divided between the generating system and the lamps themselves. The former consists of two units in exact duplicate, and each of which is therefore of the type illustrated in the accompanying engraving, from which it will be seen to consist of a three-cylinder gas engine, from which is driven a generator that in turn drives an exciter, all being self-contained in a van. To particularize, the engine is of the standard three-cylinder, four-cycle type, giving power at each two-thirds stroke, as manufactured by the Marinette Iron Works Manufacturing Company, of Chicago Heights, Ill., under the Walruth patents. This engine runs at a speed of 425 revolutions per minute, and it drives the generator at a speed of 750 revolutions per minute by means of a steel link belt that meshes into projections on the respective pulleys after the manner of a sprocket chain and wheel. As will be seen from the illustration, the exciter is belt-driven from the outer end of the generator shaft.

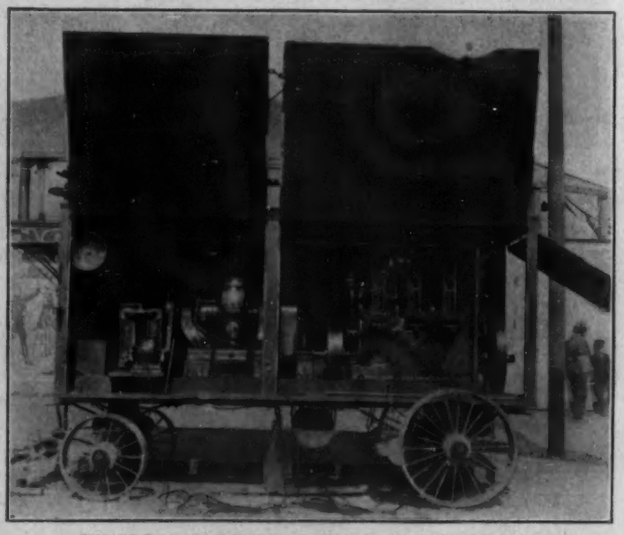
The generator is of the Wood alternating-current type, as manufactured by the Fort Wayne Electric Works. It is a single-phase machine, rated at eighteen kilowatts and delivering current at 226 volts and sixty cycles from a revolving armature and fields of the composite type. The exciter is rated at an output of one kilowatt at 110 volts. It may be readily understood that in traveling through the country the apparatus is subjected to much abuse by reason of rough roads, while on the other hand it becomes imperative to use any grade of gasoline or distillate that may be available, but despite these handicaps the performance of the plant is remarkably good, for during the four months that it had been in use prior to its arrival in San Francisco, it had been out of commission in but a single instance, when an hour was lost because of an engine trouble.

The switch-board, which is shown in the second illustration, is also of a portable type, and is of extreme simplicity, as it consists merely of an exciter rheostat, an alternator field rheostat, a voltmeter, an ammeter, a set of inclosed fuses and the knife switches necessary for the control of the lighting circuits. The switch-board may be placed near the generating plant, or within the main tent, as circumstances may dictate, and it gives every function of control that is necessary.

Thirty-six six-glower Nernst lamps of the ordinary outdoor type furnish ample illumination for lighting the interior of the great main tent, although as a precaution, necessary because of a certain element of unreliability which enters into the operation of gas engines, six double-burner gasoline torches are kept burning as well throughout each night performance. These thirty-six lamps are of the ordinary standard outdoor variety, with cast-iron protective hoods, and they are arranged in groups of six about each one of the six main masts that support the tent. The method of supporting these groups is unique, particularly because of the rapidity with which they may be erected or knocked down. From a collapsable wrought-iron ring encircling each mast are



NERNST LAMPS AT RINGLING'S CIRCUS



ONE OF RINGLING'S PORTABLE GAS ENGINE-GENERATOR UNITS

THIS IS ALL THERE IS TO THE MAIN SWITCHBOARD

projected six arms that radiate like the ribs of an umbrella, with the exception that each arm is hinged at the center, in order to economize the space that would otherwise be used because of their length. When fully extended the lamps are supported on the extremities of these ribs, so as to form a circle of a diameter of about fifteen feet. Hanging from one of the ribs is a special cast-iron switch and fuse-box, with a set of main fuses, giving control to the six lamps as a group, or to either lamp individually. All lamps are run in parallel—that is, at nominally 220 volts—and the managers of the circus declare that the illumination resulting therefrom is far superior to any other mode of artificial lighting.

In addition to these lamps, there are used within the rings four "spot" lamps, by means of which light is concentrated in spectacular work. Other lamps of the same type are used in the various auxiliary tents, side shows, dressing rooms, etc., while the office van is illuminated with 220-volt incandescents.

Further features of interest lie in the devices which are used to expediate the handling and repair of the equipment. Special boxes are provided for the different groups of lamps in the main tent, and each box, one of which appears in the last illustration, contains six lamps and the cast-iron fuse boxes which accompany them. The entire equipment is carried in a circus van, which is illustrated herewith and which serves as well for a repair wagon. In the latter exigency a box or cable reel becomes improvised as a work bench on which repairs are made, as the engraving portrays.

The entire installation is intrusted to the care of H. P. Moss, of Springfield, Ohio, to whom the writer is indebted for details of the interesting equipment.

ESTABLISHING ANOTHER BRANCH OFFICE.

The Electric Controller and Supply Company, of Cleveland, desire to announce the opening of its Southern branch office at 509–510 Woodward Building, Birmingham, Alabama. This company is now represented in the following cities: New York, Philadelphia, Pa., Pittsburg, Pa., Cleveland, O., Birmingham, Ala., Denver, Colo., San Francisco, Cal., and London, Eng.

MOTOR-DRIVEN SHOP TOOLS AT ST. LOUIS.

AN epoch in the development of electrical motor-driven machinery is marked by the World's Fair exhibit of the Electric Controller and Supply Company, of Cleveland. Heretofore it has been the custom to use some form of friction clutch with motor-driven planers. The controller company has accomplished the seemingly impossible, however, and has developed a controller which makes it possible to gear the motor directly to the cross-shaft of the planer. The apparatus necessary to a complete outfit consists of a variable speed motor, an accelerating controller, a reversing switch, a speed controller and a small bank of resistance. The reversing switch is automatic, but is provided with a hand lever by which the operator can bring the planer to a stop at any moment. He also uses this lever to set the length of stroke and determine the position of the reversing dogs. The dogs then operated this switch automatically at the proper moment.

The function of the accelerating controller is to bring the armature to a stop, reverse it and bring it up to speed so smoothly and quickly that a total stroke as short as five inches has been obtained with absolutely no sparking at the brushes of the motor. The amount of overload is accurately predetermined.

The speed controller is located so as to be convenient to the operator and has a handle with a notch wheel and graduated dial. He can turn it to give him the most economical cutting speed for the work in hand and can change it at will while running. This feature is a great advance over the friction clutch drive, which required a change of gears to change the cutting speed, entailing great loss of time and generally not giving the most economical cutting speed after all. The return speed is usually fixed at twice the highest cutting speed, except in case of a planer which cuts both ways, where a speed controller is provided for return also.

The company has a thirty-six-inch Pond planer, so equipped in operation at its St. Louis exhibit, and has another in successful commercial operation in the machine shop of the Wellman-Seaver-Morgan Company, in Cleveland, and is now working on several additional equipments. It would be pleased to show the same to any one interested, and to send its Bulletin No. 1008, which describes this drive.

RINGLING'S EQUIPMENT AND REPAIRING VAN

This same controller is also adapted to reversing mill table motors. The amount of overload is predetermined, making it impossible for the operator to damage the motor. The company also prints a bulletin describing this controller.

AN INTERESTING FUSE EXHIBIT AT ST. LOUIS.

THE exhibit of Sachs' "Noark" inclosed fuses and fuse devices, made by the H. W. Johns-Manville Company, in the Electrical Building, at the St. Louis Exposition, impresses the observer at once that the inclosed fuse, as an electrical accessory, has obtained a permanent position in the electrical field.

While the exhibit is not large it is thoroughly representative and shows to excellent advantage the various inclosed fuse devices of different types and styles manufactured by this concern. It is

mounted on a large display board, rising from the center of a handsome oak table. Over all is suspended an enormous inclosed fuse, duplicating the actual device in every particular. Mounted on both sides of the display board are the different styles of fuse blocks equipped with their respective fuses, one side of the board being covered with 220-volt devices, while the other presents the higher potential appliances. The display of blocks and fuses is very comprehensive, including every standard block and fuse manufactured by the company.

Placed upon the table on each side of the display board, and also on the floor underneath the table, is a complete line of fuse and service boxes, with the lobster-claw, fuse-clamping arrangement, and also a line of car equipment fuse boxes, subway boxes, etc. An attractive feature is the actual demonstration which is given from time to time of the operation of open and inclosed fuses. The exhibit includes a testing box containing an open fuse block and a Sachs "Noark" inclosed fuse block The open fuse is first blown with the usual terrific explosion, while the inclosed fuse opens the circuit, so that unless one looked at the indicator, with which the fuses are equipped, it would be impossible to know whether the fuse had blown or not.

The Sachs "Noark" inclosed fuse is claimed to be the pioneer indicating inclosed fuse, and the excellence of the device and the work done by the inventor, Joseph Sachs, in the invention, development and exploitation of inclosed fuses, has already received hearty approbation, not only of the public, but of the Franklin Institute of Arts and Sciences, which awarded Mr. Sachs the John Scott Legacy Medal and Premium, on October 14, 1903.

A THESIS ON DOBLE REGULATING NOZZLES.

In June, 1903, Messrs. H. C. Crowell and G. C. D. Lenth completed a series of elaborate investigations upon the performance of the Doble needle regulating nozzle in the laboratory of the Massachusetts Institute of Technology, Boston, of which institution they were students. The results of these investigations were duly presented in the form of a thesis, which has now been reprinted by the Abner Doble Company, San Francisco, as Bulletin No. 6. It is a valuable pamphlet, replete with illustrations, tables and hydraulic data, and will be mailed gratuitously by the Abner Doble Company to all interested.

THE ALLIS-CHALMERS COMPANY.

The progressive energy which has marked the development of the Allis-Chalmers Company continues to be displayed, as indicated by the further strengthening of its mechanical and sales forces with the appointment of the following men, whose ability placed them high in the ranks of other companies: Sales department—R. L. Richardson, Pittsburg office; John V. Redfield, Chicago office; James Ashworth, salesman in the pumping engine department; Otto Clyde Ross, as engineer and salesman; Charles F. Adae, New York office; S. H. Sharpsteen, New York office; G. Fred Collins, special representative at the New York office; W. M. S. Miller has joined the Chicago staff; Charles S. Buell, salesman and engineer in the power department; John F. Burke will engage in the sale of Corliss engines, electrical apparatus and crushing and cement machinery at Omaha; Wilber M. Ruth Pittsburg office.

A NEW MANAGER FOR THE WEST COAST MANUFACTURING COMPANY.

Some time ago we chronicled the death of Andrew White, president and manager and also the founder of the West Coast Manufacturing Company, of San Francisco. The directors, in looking around for the proper man to succeed Mr. White as manager of the company, secured the services of O. A. Hoit, of Sacramento, who, although still a young man, has been identified with electrical and telephone interests for a number of years. The company was reorganized with Mr. Hoit as president and general manager; G. F. Diedel, vice-president; George F. Holbrook, secretary and treasurer, and Drew White, superintendent. The factory facilities, on Sacramento Street, were found to be inadequate, and larger quarters were secured at 141–143 Main Street, where the output has increased over 100 per cent. The chief product of the plant is the "Sunset" dry battery. The company also manufactures the "Tempest" dry cell, which they supply to those who do not wish a high grade cell. They also make battery zincs and carry in stock sal ammoniac, blue vitriol and manganese.

ANOTHER CONTRACT SECURED.

The General Incandescent Arc Light Company, 529 West Thirty-fourth Street, New York, has been awarded the contract for 1250 G. I. dust and water tight outlet boxes, for the new John Wanamaker building, at Philadelphia, through the Pennsylvania Electrical Equipment Company.

ANOTHER CONTRACT AWARDED.

The Washoe Power Development Company, Reno, Nevada, of which J. E. Humphrey is president, has awarded the contract for its power house and substation electrical equipment to the Stanley Electric Manufacturing Company, through the latter company's San Francisco office. The equipment includes one 750-kilowatt generator, two seventy-kilowatt exciters, three 300, two 250 and three 125-kilowatt transformers, six switchboard panels and two substation equipments. The Stanley Company reports the sale of nearly 20,000 kilowatts high tension, 60,000-volt transformers on the Pacific Slope during the past three weeks.

THE KNOWLES "EXPRESS" PUMP.

The Knowles Steam Pump Works, 114 Liberty Street, New York City, is distributing Bulletin K-3, describing its recently designed "Express" pump. This pump is of the reciprocating type, and is directly connected to an electric motor, without gears or belts, a 250-gallon pump running at a speed of 300 revolutions per minute. In a test, the details of which are given, this pump showed an efficiency of 93 per cent. Pumps of this type are built in capacities of from 200 to 4000 gallons per minute and for heads from 100 to 2000 feet.

MEXICAN INDUSTRIALS.

The new electric power and light company of Colima is making rapid progress with its work, and by next May will have both power and electric light in Colima.

The Compania Explotadora de Carbon de Michoacan, which owns coal fields in the vicinity of the town of Agostitlan, proposes to construct a railway from the mines to Irimbo, a distance of about thirty-five miles, and will probably extend the line from the latter point to connect with the Mexican Central Railroad at San Juan del Rio.

The Esperanza Mining Company, which operates a large property in the El Oro district, Mexico, is to abandon the use of steam power for electricity. The current will be transmitted from the Necaxa plant of the Mexican Light and Power Company. J. T. Hill, electrical engineer, Mexico City, is in charge of the Esperanza installation work.

Several capitalists of Chihuahua, Mex., are interested in the building of a dam in Rincon de Chubiscur, Chihuahua, for irrigatiod purposes. Governor Terrazas appointed a committee of engineers to make a report on the work and the probable advantages accruing from the dam. The first portion of the report has just been received and is satisfactory.

D. G. C. MacNeill, of Guanajuato, Mex., and Colorado Springs, Colo., has bought the Ferrocarril Urbano de Colima (the city and suburban railroad of Colima). The price was in the neighborhood of $50,000, gold. Several improvements and additions to the present plant will be made, and by next year the plant will be operated by electric power. Mr. MacNeill is largely interested in mines in the Guanajuato district and also in Cripple Creek, Colo.

A committee of twelve representative men of the Republic of Mexico, including Senator Carlos Rivas, met at the Sanz Hotel, City of Mexico, October 15th, to formulate plans to promote the industrial interests of the Republic. It is the intention of the committee to establish a bureau of information concerning the resources and developments of the country and send reports to the leading financial men of the United States and other countries.

The Department of Fomento has granted a concession to Sr Victor Gutierrez to utilize the waters of the Lerma River, in the State of Guanajuato, using up to 400 liters per second for irrigation purposes. Work on the plans must be begun within six months and the plans when completed approved by the department. Construction work must be started within two years and finished within seven. Permission is given to construct the necessary canals and ditches and to expropriate such land as may be needed to properly carry out the work.

A concession has been granted to the Chihuahua Mineral Railway for the construction of various ærial lines in the municipality of Santa Eulalia, designed to facilitate the transportation of ores from the mines to the railway. Concessions have also been granted to Colonel Antonio Ramos Cadena for building tramways in the town of Camargo; to Senores Julio Lopez Velarde and associates for tramways in Aldama; to Licenciado Felipe Seijas and associates for the establishment of an electric plant in Ciudad Juarez, opposite to El Paso, on the Rio Grande boundary.

The Department of Fomento has granted a concession to F. P. Moreno, representing the National Iron and Steel Works, S. A., for the installation of a water gas plant. This gas works will be installed in the place most convenient for the company and must conform with the sanitary law. The company must invest at least $100,000 in the business within ten years. A deposit of $5000 in bonds of the consolidated debt is required as a guarantee of good faith. The Government reserves the right of admission for two students of the national schools to study the proceedure and machinery and the company obligates itself to give all information required.

NEW INCORPORATIONS.

SAN FRANCISCO, CAL.—The Stanislaus Power Company; capital stock, $5,000,000: directors, Sidney Sprout, J. P. O'Brien, M. L. Rosenfeld, E. E. Peabody and J. A. Thomas. The company will develop from 15,000 to 20,000 horsepower.

PINE CITY, WASH.—The Interstate Telephone and Telegraph Company; capital stock, $5000. The company will build lines to Thornton, St. John and other points in Washington.

AMERICAN FALLS, IDAHO.—The American Falls Electric Company, Ltd.; capital stock, $100,000; incorporators, William and John Burke, S. V. St. Clair, of American Falls, and others.

TUCSON, ARIZ.—The San Diego Realty and Development Company; capital stock, $250,000; incorporators, J. J. O'Brien, Henderson Hayward and others, of California. The object is to develop electric power plants, railroads, water and power plants, pipe lines, etc.

COLUSA, CAL.—The Northern Electric Railway and Navigation Company; capital stock, $3,000,000; incorporators, J. N. Miller, E. J. Miller, W. H. Buster, E. B. Vann and others. The object is to operate an electric road from St. John, on the west side of the Sacramento River, to Colusa, and from Butte City to Chico.

LOS ANGELES, CAL.—The Superior Light and Heat Company; capital stock, $100,000; incorporators, S. L. Kistler, S. A. Brown, D. M. Brown, J. W. and W. S. Badger, all of Los Angeles. The company has established a factory and offices in East Fourteenth Street. It manufactures automatic carbide feed acetylene generators and stove burners.

SEATTLE, WASH.—The Seattle, Everett and Skagit Electric Railway Company; capital stock, $2,000,000; incorporators, W. H. Goldson, of California; P. J. Farley and Edwin S. Gill, of Seattle, and others. The company will construct an extensive interurban system north of Seattle, Wash. Franchises have been granted by King and Snohomish counties. Work will commence as soon as the plans are completed, the money having been raised.

WASHINGTON, D. C.—The National Electric Company, of Mexico, has been incorporated with a capital stock of $5,000,000. The incorporators are P. H. Burch, Ralph Wormelle, D. K. Pearce and R. K. Van Mater. It is stated that the company has secured a franchise in Chihuahua, Mexico, and has obtained control of the mule tramway, which will be converted into an electric railway. There are six miles of track in the city and fifteen miles running to the mines at Santa Eulala.

SAN FRANCISCO, CAL.—The United Electrical Construction Company; capital stock, $100,000: incorporators, E. L. Andrews, C. P. Lofthouse, H. L. Worthington, L. C. Edwards, W. G. Wil-

lits, M. J. Sullivan and J. S. McDonald. Offices have been opened in the Grant Building, Seventh and Market streets. The company will engage in the construction of electric light and power plants and pole lines. The company is composed of men who are well known in the electrical fields of the Pacific Coast states.

TRANSMISSION.

REDDING, CAL.—Work has been commenced on the big power plant to be erected at Horseshoe Bend, at Battle Creek.

SAN BERNARDINO, CAL.—The Mentone Power Company intends to build another power house in Santa Ana Canyon. Equipment has been purchased.

ALAMEDA, CAL. The Trustees of Alameda have instructed the clerk to advertise for bids for new machinery for the city light plant.

EUREKA, CAL.—The North Mountain Power Company has commenced the construction of its $50,000 auxiliary plant at Eureka, Cal.

WEAVERVILLE, CAL.—Mark Manley, superintendent of the Enterprise Mine at Weaverville, is figuring on installing an electric plant at the mine.

GUADALAJARA, MEX.—Carlos Navarro Mora has petitioned the Mexican Government for a concession to establish an electric light plant at Capala.

KORBEL, WASH.—It is the intention of the Humboldt Lumber Mill Company to install an electric light plant at Korbel which will have a capacity of 600 lights.

SEATTLE, WASH.—City Engineer Thompson has gone to Cedar Lake, Wash., to superintend the work of rushing the municipal lighting plant and the pole line to completion.

SALT LAKE, UTAH.—James J. Chambers, of Salt Lake, Utah, is planning the installation of electric light plants in Big and Little Cottonwood canyons a few miles southeast of Salt Lake.

MONTERREY, MEX.—Van Voorhees Brothers have obtained a contract from Berlanga Brothers, of Montemorelos, for the construction and equipment of a power plant for lighting purposes for that city.

NEW WESTMINSTER, B. C.—E. J. Fader, of the Fraser River Tannery, New Westminster, B. C., intends to build an electric power plant to develop about 1,000 horsepower to be used for private purposes.

ALAMOGORDO, N. M.—It is probable that Artesia, N. M., will have an electric light system in the near future. E. H. Fisher, of Alamogordo, has been looking over the ground with a view to putting in a plant.

EUGENE, OR.—J. F. Wilson, of the Willamette Valley Electric Railroad Company, at Eugene, Or., says that the company will put a corps of surveyors out to survey three different power plant sites for the big system.

OROVILLE, CAL.—Colonel Henshaw and his associates intend to construct a power plant at Oroville to furnish electricity for light and power purposes as soon as a franchise is granted. It is probable that lines will be run to Chico and Marysville.

FLORISTON, NEV.—A new power plant to keep the Comstock mines clear of water has been contracted for. It will be constructed on the Truckee River about two miles down stream from Floriston, and will be erected by the Floriston Power Company.

RIALTO, CAL.—The Improvement League of Rialto has appointed a committee, consisting of William Buxton, J. C. Boyd and A. B. Paddock, to confer with one of the electric companies in regard to securing power for use in the packing houses and for lighting the town of Rialto.

HAINES, OR.—The Council of Haines, Or., has granted J. F. O'Bryant a franchise to conduct an electric light and power system within the corporate limits of the town.

TAMPICO, MEX.—The work of installing a series of storage batteries for the electric light plant at Tampico, Mex., will be commenced in the near future by Fabrica de Acumuladores, S. A. Several other batteries are to be installed by this company in mining plants in Mexico after the first of the year.

NEW WESTMINSTER, B. C.—The State River Falls Power Company will issue $900,000 worth of debentures, the proceeds of the sale of which will be devoted to power development. The falls of the company are about forty miles from New Westminster, B. C., and it is estimated that 25,000 horsepower is available.

CITY OF MEXICO, MEX.—The concessionairs of the power concession obtained by Facundo Perez, Lazcro Lepetich, Salvador Garcia and Latour de Vazquez, on the Santiago River, claim to have 30,000 horsepower in sight, and the present proposition is to harness and transmit the same to Aguascalientes, 110 miles distant.

PORTLAND, OR.—The Tucker Power Company proposes to erect a power plant at the Tucker bridge, five miles up Hood River, in Oregon. At Chenoweth, five miles below Hood River, Engineer Oliver, of the Columbia River Northern, has been running surveys for the purpose of locating a power plant. Electricity is to be transmitted to Portland.

ALBUQUERQUE, N. M.—The Albuquerque Electric Power Company, recently organized, has started work on the construction of a plant north of the mills of the American Lumber Company which will generate between 1500 and 2000 horsepower. The company will furnish current to the Albuquerque Gas, Electric Light and Power Company. E. C. Allen is manager of the company.

WALLA WALLA, WASH.—A modern power and light plant is being installed on the South Fork of the river about fifteen miles from Walla Walla, Wash., to cost about $300,000. It will supply electric light and power for Walla Walla, Wash., and Pendleton, Athena and Weston, Or. Samuel Storrow, of Los Angeles, Cal., is constructing engineer, and N. Larson is superintending the work.

FORT STEELE, B. C.—The Bull River Falls Power and Light Company, recently organized, has started work on the construction of a dam and will build an electric power plant early next spring to develop 10,000 horsepower. George E. Henderson, of Fort Steele, is one of the prime movers of the company. From the prospectus issued it appears that the company has a favorable proposition.

SAN JOSE, CAL.—The Tuolumne Electric Company, of which H. W. Hersey, of San Jose, is president, and C. W. Quilty, of the same place, secretary, has filed a certificate of the creation of a bonded indebtedness of $60,000, the proceeds to be used for the purpose of purchasing hydraulic and electric machinery and the construction of an electric plant. This action is the final step toward the completion of the plans for the erection of a large electric plant on the Tuolumne River by San Jose capitalists.

REDDING, CAL.—The United States Mining Company, of Boston, Mass., will spend about $600,000 for improvements at its recently acquired Mammoth Mine, near Redding. The electrical equipment to be purchased includes motors as follows: Three 200, two 50, one 35, one 15, and two 5 horsepower motors and one 22-kilowatt motor-generator set. Two surface locomotives with a speed of eight miles an hour will also be purchased. Current will be secured from the Northern California Power Company.

SALT LAKE, UTAH.—The new electrical transmission station to be built by the Utah Light and Railway Company will be equipped with the latest electrical contrivances. The building is to be erected on the banks of the Jordan River, between South Temple and First South streets, Salt Lake, Utah. It will be 45x100 feet, and will be entirely of brick and steel. Each transformer bank will be placed in a separate compartment of brick and steel. This station will be called the Jordan substation, and will be supplied with power by the Ogden, Big Cottonwood and Bear rivers and the Telluride Company, of Provo and Logan, Utah.

LEWISTON, IDAHO.—The Lewiston-Clarkston Company, recently organized with $2,000,000 capital stock, has established headquarters at Lewiston, Idaho. The company has merged the Lew-

iston Water and Power Company, the Lewiston Light Company, Ltd., the Clarkston Water Works and the Asotin Land and Water Company. Plans are being outlined for extensive developments in that territory, which will necessitate the expenditure of close on to $2,000,000. E. H. Libby is president of the company; William Wheeler, of Boston, is supervising engineer; W. E. Moore, civil engineer, and A. E. Ransom, formerly with the Westinghouse companies, is electrical engineer.

TRANSPORTATION.

SAN BERNARDINO, CAL.—It is rumored that the San Bernardino Traction Company will in the near future extend its line to Rialto.

NEWPORT BEACH, CAL.—Surveyors are running a line to Newport Beach for a continuation of the electric road from Huntington Beach.

SANTA MARIA, CAL.—The Santa Maria Light and Power Company is arranging to put in an electric road between Santa Maria and Guadalupe.

SACRAMENTO, CAL.—An electric railroad is projected for Martinez and the surrounding country. The matter is being seriously talked of among the capitalists of the town.

ELBERTON, WASH.—The contract for grading the roadbed for the electric railroad from Colfax to Palouse, Wash., has been awarded to J. M. Bodine, of Elberton, Wash.

SAN JOSE, CAL.—Surveyors will soon be in the field to map out a route for the electric road from San Jose to Mount Hamilton, as planned by the Mount Hamilton Exploitation Company.

SAN DIEGO, CAL.—The San Diego Electric Railway Company has asked the Council of San Diego for a franchise to construct an electric railway running from M Street around to the cemetery.

SAN JOSE, CAL.—The Sempervirens Club committee has returned to San Jose from an inspection of possible highway and electric line routes from San Jose into the Big Basin State Park by way of Saratoga.

VICTORIA, B. C.—The British Columbia Electric Railway Company contemplates the construction of a tramway line running from the Esquimalt road along the Cauliflower road to the park at the Gorge.

TACOMA, WASH.—The street railway franchise scured at Tacoma, Wash., by Stuart Rice, is to be taken up by a syndicate of Eastern capitalists. W. J. Murphy says work will begin in a short time.

SONOMA, CAL.—The Supervisors of Sonoma County have received an application from S. Shocken and Oscar T. Weber for an electric railroad franchise from Sonoma to tidewater at Embarcadero.

SPOKANE, WASH.—The Spokane Power and Transportation Company is having surveys made for an electric railroad from Miles to Spokane, Wash. Jules Pricket, of Spokane, is president of the company,

SEATTLE, WASH. The Seattle Electric Company will extend its electric lines in the city, which under its franchise from the Seattle officials mustbe completed by December 31st next.

SANTA ROSA, CAL.—The Council, of Santa Rosa, Cal., has passed an ordinance granting to the Petaluma and Santa Rosa Railway Company a franchise to construct and operate an electric road along the streets of Santa Rosa.

SPOKANE, WASH.—Evan Morgan, manager of the Loon Lake resort at Washington, is authority for the statement that an electric road will be built from Spokane to Loon and Deer lakes. He states that Spokane parties are back of the project.

CITY OF MEXICO, MEX.—Ernesto Pelaez, calle de Zuleta 18, City of Mexico, together with Captain Charles Holt and Benjamin Barrios, will build an electric railway between the City of Mexico and Pueblo, a distance of 120 kilometers. A preliminary survey of the route is being made.

WATSONVILLE, CAL.—The bonds of the Watsonville Transportation Company have been taken up by Marshall A. Frank, of San Francisco. This issue amounts to $300,000, the sum estimated to cover the cost of the extension of the road beyond Vega. It is the intention of the company to commence construction immediately and to push the work with all possible diligence.

SAN BERNARDINO, CAL.—The celebrated Waterman Ranch, consisting of 600 acres and owned by the heirs of the late Governor Waterman, has been sold to a syndicate of San Bernardino capitalists consisting of Dr. G. W. Tape, Seth Marshall and others. It is the intention to run an electric railway to the site of a proposed new sanitarium, and in time continue to the summit of the mountains.

PORTLAND, OR.—F. I. McKenna, of the Portland and St. Johns Railway Company, announces that a new company will be formed for the purpsse of building another electric railway down the peninsula to St. Johns, Or., provided the Consolidated Car Company does not care to build the branch from North Albina. Negotiations are progressing favorably, but the new company is not in the market for equipment just yet.

SAN FRANCISCO, CAL.—It is stated that H. E. Huntington is behind the project to establish an electric railway between Oakland, Sacramento and Marysville, which has been chartered as the Oakland and Marysville Railroad Company, and that this road is destined to be a link in the chain of electric railway systems which the Huntington interests propose to eventually build through the length of the interior of the State.

KAYSVILLE, UTAH.—The Council of Kaysville, Utah, has granted a franchise to B. Mahler to construct an electric railway through Kaysville city on any street he may select. The franchise is granted for 100 years and allows three years for construction. Mr. Mahler expects to construct an electric road from Payson to Logan, and has secured a number of franchises from other cities similar to the one granted at Kaysville.

PALO ALTO, CAL.—The supervisors of Santa Clara County have granted a franchise to the Interurban Company for an electric railway from San Jose to Palo Alto. The road will connect with the San Jose and Saratoga line at the intersection of the Stevens Creek highway and Saratoga Avenue. Surveyors are now at work on the proposed line, which will pass the new Santa Clara College site west of Mountain View, also Stanford University.

SAN JOSE, CAL.—O. A. Hale, as president of the San Jose and Palo Alto Interurban Railroad, has filed the company's petition for a franchise with the Board of Supervisors of Santa Clara County, Cal., to construct and operate an electric railroad on the Stevens Creek road from Saratoga Avenue, at the Meridan Corners, San Jose, to Stevens Creek, near the father's villa. Bids for the franchise will be received by the Supervisors on November 9th.

TELEPHONY.

WAITSBURG, WASH.—Emmet Henderson, and others have completed the new telephone system.

CALEXICO, CAL.—The Arizona Consolidated Telegraph and Telephone Company has purchased the telephone system extending from Old Beach to Calexico, Cal., with branches to Holtville and Silsbee.

PHŒNIX, ARIZ.—H. M. Joy, manager of the Independent Telephone Company, has gone to San Francisco and the East on business connected with the telephone system which he expects to install at Phœnix, Ariz.

LOS ANGELES, CAL.—Material is arriving at Phœnix, Ariz., for the extension and construction of the Sunset telephone line between Phœnix, Ariz., and Los Angeles, Cal. Poles are being shipped from Puget Sound, Wash.

OCEAN PARK, CAL. The Home Telephone Company has begun active construction work on the installation of its system at

Ocean Park, Cal. The company is planning the erection of a building at Saeta Monica and one in Ocean Park.

SAN LUIS OBISPO, CAL.—The Supervisors of San Luis Obispo County will receive sealed bids up to November 9th for a franchise to construct and maintain a telephone system in San Luis Obispo County, as applied for by Adolph Phillips.

SEATTLE, WASH.—The International Telephone Company will start construction work at once on the proposed telephone line from Bellingham, Wash., to Victoria, B. C. There will be seventy miles of land wire and fifteen miles of cable. The cost will be about $100,000.

EVANS, MONT.—The Cascade County Rural Telephone Company, of which Duncan Cameron; of Black Butte, Mont., is at the head, is preparing to build twenty-five to thirty miles of line from Black Butte to Great Falls. The line will eventually spread over a much larger territory.

SALT LAKE, UTAH.—The Rocky Mountain Bell Telephone Company is constructing a line to Roosevelt, in the Thunder Mountain district of Idaho. D. S. Murray, general manager of the company, states that a branch line to the Big Creek country will likely be constructed next spring.

DAYTON, WASH.—J. H. Romaine, George Jewett, F. C. Romaine and N. James are interested in the construction of a new telephone line from Dayton, Wash., to J. H. Romaine's ranch, about seven miles from Dayton. Work will begin at once. The company will be known as the Happy Flat Telephone Company.

WATER WORKS.

PRICE, UTAH.—The Utah Fuel Company has decided to establish a water system at Sunnyside at once.

SANTA ANA, CAL.—It is probable that the Council of Santa Ana will submit to the people the matter of issuing $100,000 bonds for improvements to the water system.

REDWOOD CITY, CAL.—The Trustees of Redwood City have passed an ordinance providing for the issuance of $35,000 for the acquisition of water pipe for a municipal water works system.

GRASS VALLEY, CAL.—The Supervisors of Nevada County are advertising for bids for furnishing material and performing work on a new water system at the County Hospital at Grass Valley.

MORENA, CAL.—The water system of the Southern California Mountain Water Company, owned by John D. and Adolph Spreckels, is to be completed as soon as possible. Reservoirs are planned at Morena and Barrett.

WADSWORTH, NEV.—The Wadsworth Power and Electric Company is negotiating with the citizens committee of Wadsworth, Nev., to build a large reservoir on the hill east of town where water will be stored and piped to the town.

MOUNTAIN VIEW, CAL.—The Trustees of Mountain View have adopted the plans and specifications of Civil Engineer Moore for a municipal water works system, and bids for the construction of the system will be advertised for in the near future. A pumping plant is to be erected and a distributing system installed.

SAN DIEGO, CAL.—A special committee appointed by the City Council of San Diego is making investigations relative to the desirability of installing a second independent water pumping plant in the San Diego River for water supply. The proposition is to bring the water through a flume or pipe line fifteen miles, the plant to be on water bearing lands above the Old Mission dam.

SAN Francisco, CAL.—The Hilo Water Company, Porterville, Cal., has awarded the contract for its work, to cost $4000, to the G. W. Price Pump Company. The equipment will include a thirty horsepower motor, six-inch centrifugal pump, high potential transformers, pipe line, etc. The latter company has also secured the contract for a 100 horsepower reclamation plant near Stockton, Cal., including a twenty-inch centrifugal pump.

SAN FRANCISCO, CAL. The South San Francisco Land and Improvement Company has purchased from the Abner Doble Company a compound centrifugal pump to be driven by a seventy-five horsepower induction motor. Power will be supplied by the South San Francisco Power and Light Company, recently organized, which is building a substation to contain a full distributing system, the current to be obtained from the Standard Electric Company. The Abner Doble Company is consulting and supervising engineer in the construction of the substation.

GAS.

COVINA, CAL.—Dr. J. D. Reed, H. M. Houser and J. H. Coolman, of Covina, Cal., have secured a franchise from the city for a gas plant. A company is to be organized and a plant built to supply Covina and perhaps Azusa and Glendora.

NORTH TACOMA, WASH.—The City Council has decided to compel all applicants for gas franchises to put up guaranty bonds to cover any expense the city might be put to in the event parties securing such franchises fail to carry through their plans. This action was deemed advisable on account of the fact that franchises previously granted were not carried out.

LOS ANGELES, CAL.—The Los Angeles Gas and Electric Company has just finished a 1,000,000-foot gas holder at Jackson and Center Streets, and has made additions to the generating apparatus which amounts to an increase of 2,000,000 cubic feet a day. The company is using about 1000 barrels of fuel oil a day for the generation of power. The improvements made in the equipment of the company during the last year, it is claimed, cost over $750,000. Preparations are being made for the installation of 175 additional 2000-candle-power street lights authorized by the City Council, this company having secured the contract.

ILLUMINATION.

OCEANSIDE, CAL.—J. Johnson, Jr., president of the Escondido Vineyard Company, Escondido, Cal., has secured a gas and electric light franchise from the city of Oceanside, San Diego County, Cal.

MISCELLANEOUS.

SAN FRANCISCO, CAL.—The Martland Electric Company has removed from 33 Beale Street to much more commodious quarters in the Van Arsdale Building. The company is engaged as contracting electrical engineers.

SAN FRANCISCO, CAL.—The Cook-Raynor Belting Company, recently organized, has remodeled the plant formerly occupied by the Pioneer Belting Company, 850 Division Street. Additional machinery has been installed and the capacity of plant has been considerably increased for the manufacture of belting.

INDEPENDENT OIL PRODUCERS ORGANIZE.

SAN FRANCISCO, CAL.—A charter will shortly be applied for by the Independent Oil Producers Agency, which has been in process of formation the past month for the purpose of acting as distributing agent for the independent producers of the State of California. A committee of twelve representative oil producers of the State have been working out the details of the organization and securing signatures of the producers for some time, which committee recently appointed a sub-committee of three to complete the organization. Papers of incorporation, with $100,000 paid in capital stock, will be taken out in a few days, which will be contributed by the producers joining the association. The association is being formed for the protection of the small independent producers, who have been used against each other by the large corporations to force prices down. The output of the independent producers is estimated at 1,000,000 barrels per month, or about 50 per cent. of the total production of the State. The committee of twelve consists of the following: Kern River District: Timothy Spellacy, W. S. Robb, Dr. Liscomb, C. H. Ritchie, W. W. Stevenson, T. Earley and M. V. McQuigg. Coalinga District: F. W. McNear, Frank Cleary and Samuel Shannon. Sunset District: H. W. Maxfield.